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CONTENTS

A Rapid Method for Production of a Sparkling Apple Wine 673
F. E. ATKINSON, J. F. BOWEN, AND D. R. MAC GREGOR

Effect of Fruit Variety and Maturity on Quality of Apple Wine 676
J. F. BOWEN, D. R. MAC GREGOR, AND F. E. ATKINSON

The Influence of High Temperature Holding Upon the Components of Coffee Brew. III. Hydrogen Sulfide, Sulfur Dioxide, and Sulfhydryl Compounds (Mercaptans) 679
STANLEY SEGALL AND BERNARD E. PROCTOR

On the Color of Coffee. III. Effect of Roasting Conditions on Flavor Development for a Given Color. Role of Initial Moisture Level on Roasting Characteristics of Green Coffee Beans 684
ANGELA C. LITTLE, C. O. CHICHESTER, AND G. MACKINNEY

Tenderness at Various Muscle Depths Associated with Poultry Processing Techniques 689
R. G. WISE AND W. J. STADELMAN

Fouling of Evaporator Tubes by Tomato 691
ARTHUR I. MORGAN, JR. AND THEODORE WASSERMAN

Slurry Viscosity Measurements as Methods to Determine Maturity of Lima Beans and Peas 694
ROBERT C. WILEY

A Method for Screening Flavor Panel Members and Its Application to a Two Sample Difference Test 699
BARBARA A. HALL, MAE-GOODWIN TARVER, AND JOAN G. MC DONALD

Potential Economic Impact of Food Irradiation 704
R. HAL MASON AND SAMUEL I. TAIMUTY

Qualities of Beef as Affected by Cooking at Very Low Temperatures for Long Periods of Time 707
VIANNA D. BRAMBLETT, ROBERT L. HOSTETLER, GLADYS E. VAIL, AND H. N. DRAUDT

Uniformity of Color Measure in Green Beans 711
EDWARD ROSS, RUBENA H. PAULS, AND MARGARET M. HARD

Moisture Transfer in Combinations of Dehydrated Foods 715
HAROLD SALWIN AND VIDA SLAWSON

The Effect of Grade, Weight and Class of Beef Carcasses upon Certain Chemical and Sensory Evaluations of Beef Quality 719
D. H. KROPF AND R. L. GRAF

Effect of Borates and Other Inhibitors on Enzymatic Browning in Apple Tissue 722
KARAKIAN BEDROSIAN, A. I. NELSON, AND M. P. STEINBERG

Sweetness and Acidity Adjustment in Canned Bartlett Pears 727
MARION SIMONE, L. L. CLAYPOOL, S. J. LEONARD, AND B. S. LUH

Vanilla Extract: An Improved Lead Number Determination 730
WILLIAM J. CONSIDINE

Notes and Letters
Development of the Poultry Products Inspection Act 731
FRANK G. WOLLNEY

Glossary of Some Terms Used in the Sensory (Panel) Evaluation of Foods and Beverages 733
COMMITTEE ON TASTE TESTING AND CONSUMER PREFERENCE

Volume Index, 1959 737

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IN THIS ISSUE—

THE TECHNICAL ARTICLES IN BRIEF

Rapid method *For sparkling apple wine*

A rapid method for production of a sparkling apple wine. F. E. Atkinson, J. F. Bowen, and D. R. MacGregor.

Apple growers in North America are faced with a continuing problem of finding a remunerative outlet for commercial grade fruit unsuited to the fresh market. In Europe a good proportion of the apple crop is manufactured into apple wine (hereafter called cider). However, this fruit is of specific cider varieties not normally used for culinary purposes. On this continent fermented cider has been produced commercially to a very limited extent and cider varieties are not grown. Consequently, the North American processor wishing to use cider as an outlet for surplus apples is faced with the problem of manufacturing a palatable product from what are normally dessert varieties. *Commercial Process.* On the basis of the laboratory work a schedule for manufacture of the commercial product was set up. The recommended commercial process is as follows: 1. Select reasonably sound apples free from rot and mold. 2. Wash. 3. Grind. 4. Add sulphur dioxide. In practice 2% sulphur dioxide solution is metered into the pump which delivers the pulp to the hoppers over the presses. With the volume of fruit handled approximately 48 oz. of SO_2 solution per minute is required to give 100 p.p.m. residual SO_2 in the juice. 5. Press and screen to remove coarse particles. 6. Check SO_2 level and adjust if necessary. 7. Heat to 70° F. to 95° F. (21.1° C.–40.5° C.) and add pectinase. Agitate thoroughly after 1 hour and allow to settle about 1 hour. 8. Rough filter. 9. Make up to 16% total soluble solids by refractometer with sucrose. 10. Inoculate with 1–3% of active yeast starter grown in cider stock. 11. Ferment at 77° F. (25° C.) until a refractometer reading of about 8.9% is obtained and turn on cooling coils in fermenter so that fermentation stops at 8.2%. The complete process normally takes about 4 days. Chill to 29° F. (−1.7° C.). 12. Polish filter. 13. Carbonate at about 35 lbs. pressure and store in bottling tank under refrigeration at 29° F.–32° F. (−1.7° C.–0° C.). 14. Fill bottles and close. 15. Pasteurize to obtain a bottle center temperature of 145° F. to 150° F. (62.8° C.–65.6° C.) and cool as quickly as possible. 16. Store in cool storage, until used. (See page 673.)

Varietal, maturity effects *Apple wine*

Effect of fruit variety and maturity on quality of apple wine. J. F. Bowen, D. R. MacGregor, and F. E. Atkinson.

Fermented apple ciders were prepared from seven apple varieties. Fruit freshly picked and fruit stored at 70° F. (21.1° C.) for varying periods were used. Considerable variation in quality of cider was observed. The most satisfactory ciders were those made from firm ripe fruit processed after a minimum storage period. No consistent relationship was established between the flavor of ciders and the chemical composition of the original juice, other than acidity which served to determine the composition of cider blends throughout the season. The most desirable ciders were composed of Delicious blended with Jonathan. Newtown, Winesap or Stayman Winesap could be substituted for Jonathan. In commercial production the proportion of Delicious in the blend was adjusted throughout the season so as to maintain a constant value for titratable acidity. Ripe Rome Beauty may be used to replace Delicious in blended cider. McIntosh contributed an undesirable flavor and at present is considered unsuitable for processing into cider. (See page 676).

Effect of high temperature holding *Coffee brew*

The influence of high temperature holding upon the components of coffee brew. III. Hydrogen sulfide, sulfur dioxide, and sulfhydryl compounds (mercaptans). Stanley Segall and Bernard E. Proctor.

Reports of sulfur-containing compounds in the chemical literature on coffee have raised interesting points of conjecture regarding their behavior under conditions normally associated with coffee manufacturing processes. The reported presence in coffee of some of these highly flavored, odorous substances leads to curiosity regarding the role that such compounds might play in coffee flavor. The hydrogen sulfide content of brewed coffee was determined by the use of a modification of the technique of Brenner, Owades, and Golyzniak. For the particular blend of coffee used in these studies no hydrogen sulfide was found in coffee brew. Sulfur dioxide was detected and quantitatively measured in coffee brew by a modification of the method of Brenner, Owades, and Fazio. The quantities found were below the organoleptic threshold levels reported for this compound. It was found that the content of sulfur dioxide in the coffee brew generally tended to decrease with increasing length and temperature holding. The sulfhydryl (mercaptans) content of coffee brew was determined by a modification of the technique of Brenner, Owades, and Fazio and of Brenner, Owades, Gutcho, and Golyzniak. There seemed to be a relationship between the mercaptans content of a coffee brew and the organoleptic rating of these brews. This suggests that the mercaptans content of coffee brew is closely associated with flavor and flavor changes. (See page 679.)

Measurement *Color of coffee*

On the color of coffee. III. Effect of roasting conditions on flavor development for a given color. Role of initial moisture level on roasting characteristics of green coffee beans. Angela C. Little, C. O. Chichester, and G. Mackinney.

Improvements were made on the modified Jabez-Burns Roaster previously described (*Food Technol.*, **12**, 505–7, 1958), to allow for closer temperature control and rapid

December Cover. The cover for December reflects the holiday spirit, portraying Sparkling Apple Cider, a new product researched and developed by British Columbia food technologists and now being manufactured in volume by Sun-Rype Products, Ltd., a grower-owned company located at Kelowna, B. C. The product is meeting with an excellent reception in Western Canadian markets. Color cut by courtesy of Sun-Rype Products, Ltd.

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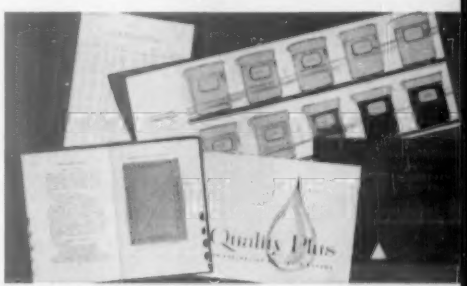

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cooling of the roasted beans. The present report extends the investigation of factors affecting color of coffee by determining the effect of the initial moisture content of beans of a given variety on the color of the finished roast. Varying conditions of time and temperature of roast to yield a product of a constant color (as meaured by its tristimulus Y value) are also explored. The objective of this phase of the investigation is to establish time-temperature equivalents and to determine the effect of roasting conditions on the flavor of a finished roast of a given color. (See page 684.)

Tenderness *Poultry meat*

Tenderness at various muscle depths associated with poultry processing techniques. R. G. Wise and W. J. Stadelman.

In view of the desirability of improving the tenderness of poultry meat, it was decided to investigate the penetration aspects of the scald problem. This paper describes (1) the tenderness pattern at different depths from the surface obtained by varying scald process techniques and (2) an objective method for measuring meat tenderness with relatively small samples. Chickens were aged in an ice and water solution for 24 hours. They were then wrapped in aluminum foil and placed in an oven at 325° F. for 2 hours. All cooked birds were cooled to 34° F. prior to removal of the breast muscle. Three slices, each 2 mm. thick were cut from the exterior surface using a commercial meat slicer. From these slices 2.5 x 6.5 cm. samples were taken and subjected to a tenderness determination using a Kramer shear press. Resistance to shear was related at a highly significant level to the depth at which samples were taken, to the temperature of scald water, and to the scald time duration. Under the conditions of this experiment, the toughening effect of high temperature-long time scald is related to the depth to which the scald heat penetrates the muscle tissue. (See page 689.)

Engineering problem *Fouling of evaporator tubes*

Fouling of evaporator tubes by tomato. Arthur I. Morgan, Jr., and Theodore Wasserman.

Many canners could triple production of tomato products if the accumulation of burned tomato inside evaporator tubes could be eliminated. In concentrating tomato, a very low solids fruit, all economies in evaporation are important. Fouling becomes intolerable when product quality begins to drop. For these reasons, engineering research has recently focussed on fouling. This paper presents evidence relating evaporator feed composition to fouling rate. Since the evidence was collected from various types of evaporators, these effects are considered applicable regardless of design or mode of operation of the evaporator. There is a selective accumulation of protein in the material fouling the walls of tomato evaporators. The foul is otherwise similar to tomato. Rupture of cells seems to increase fouling rates, probably by release of protein. Retention of pectin increases fouling. Use of an easily cleaned surface for initial fouling might reduce fouling in subsequent heat exchangers, but severe heat treatment alone is not immediately beneficial. (See page 691.)

Measurement *Quality of raw, blanched, canned vegetables*

Slurry flow measurements as a method to determine the quality of certain raw, blanched and canned vegetables. Robert C. Wiley.

Maturity measurements of vegetable crops are widely used by food processors for pre-testing, basis of payment, yard segregation, and quality control. In general these tests measure the resistance to shear, compression, or puncture characteristics of crops. Processors being faced with increased emphasis on quality are in need of a low cost, precise, multiproduct method to determine quality of vegetable crops. The proposed procedure using the Adams Consistometer to measure the rheological properties of slurries of blended vegetable timer and water appears both accurate and precise. Correlation coefficients of 0.90 or better have been determined between raw slurry flow, blanched slurry flow, and per cent A.I.S. of canned lima beans and peas. The raw slurry flow of both lima beans and peas are closely related to a shearing and pressing instrument such as the shear press. The standard deviation of raw lima bean slurries was ± .27, ¼ inch units, blanch lima bean slurries .18, ¼ inch units. The deviation of raw pea slurries was .19, ¼ inch units, blanched peas .32, ¼ inch units. The standard deviation of both commodities accounted for about .5% change in A.I.S. The standard deviation of shear press values on lima beans was ± 18.45 pounds force and for shear press converted values to tenderometer values on peas ± 1.06. The standard deviation of these measurements also accounted for about .5% change in A.I.S. Temperature was found to account for only about 2.6% of the variation in slurry flow readings. The Stormer viscosimeter and Brookfield rotational viscosimeter as

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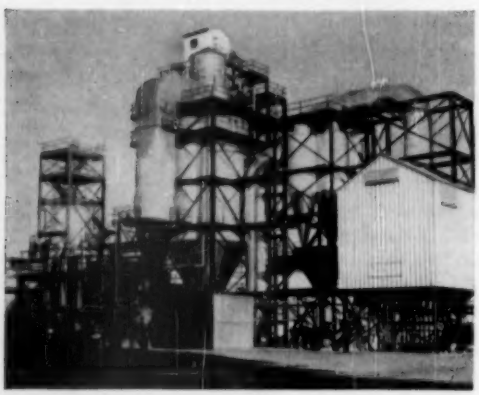

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tested did not appear suited to measure the per cent A.I.S. of the canned product. Lack of precision was the main problem with both instruments. (See page 694).

Sensory test method *For screening flavor panel members*

A method for screening flavor panel members and its application to a two sample difference test. Barbara A. Hall, Mae-Goodwin Tarver, and Joan G. McDonald.

A method for screening potential taste panel members according to their sensitivity and precision has been applied to a Two Sample Difference Test for use in selecting container materials for canned beer. The screening method involved: selection of "available," interested, well-motivated panel members; education of tasters to identified sample of specific flavor; determination of a range of concentrations suitable for the majority of the persons to be screened; determination of the sensitivity of individual persons to the specific flavor by running the suitable range of concentrations on 2 different days; and selection of those persons who are sensitive to low concentrations of the specific flavor and who can duplicate their sensitivity to this low concentration as potential "expert difference" panel members. The Two Sample Difference Test as interpreted in this paper has the following requirements: Tasters must be screened according to the prescribed method. Difference is determined between a known standard and an unknown test sample run in duplicate. Difference is recorded on a "0–5" scale with "0" indicating no difference and "5" indicating extremely large difference. A difference score must be determined for each taster when the test sample and the standard sample are identical. This score must be subtracted from any score assigned to a test sample in order to obtain the "real" difference score. The combined screening and testing methods provide a sensitive procedure for analyzing flavor difference. (See page 699.)

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Economic analysis *Food irradiation*

Potential economic impact of food irradiation. R. Hal Mason and Samuel I. Taimuty.

Food irradiation will have major impacts on several key industries. It will introduce a new flexibility into processing, transport, storage, and marketing of foods. In the food processing industry, frozen food processors may benefit most from its early impact, but canners are apt to benefit to a greater extent in the long run. Fresh produce packers will experience a reduced share of the total food market. The perfected process will introduce whole new lines of products that will require added facilities for wholesaling, storage, and retailing. Consumers will be offered a greater selection of foods with more uniform quality including precooked meats and prepared foods. The need for particle accelerators and accessory equipment will stimulate the market for electronic equipment and components. Initially, more refrigerated commercial storage equipment may be needed. Increased prepackaging of produce and meats should create an increased demand for more and better packaging. The authors assert that these economic developments cannot be expected to take place until the irradiation process has been thoroughly tested and the economics of production are better understood. (See page 704.)

Effect of cooking *Beef quality (tenderness)*

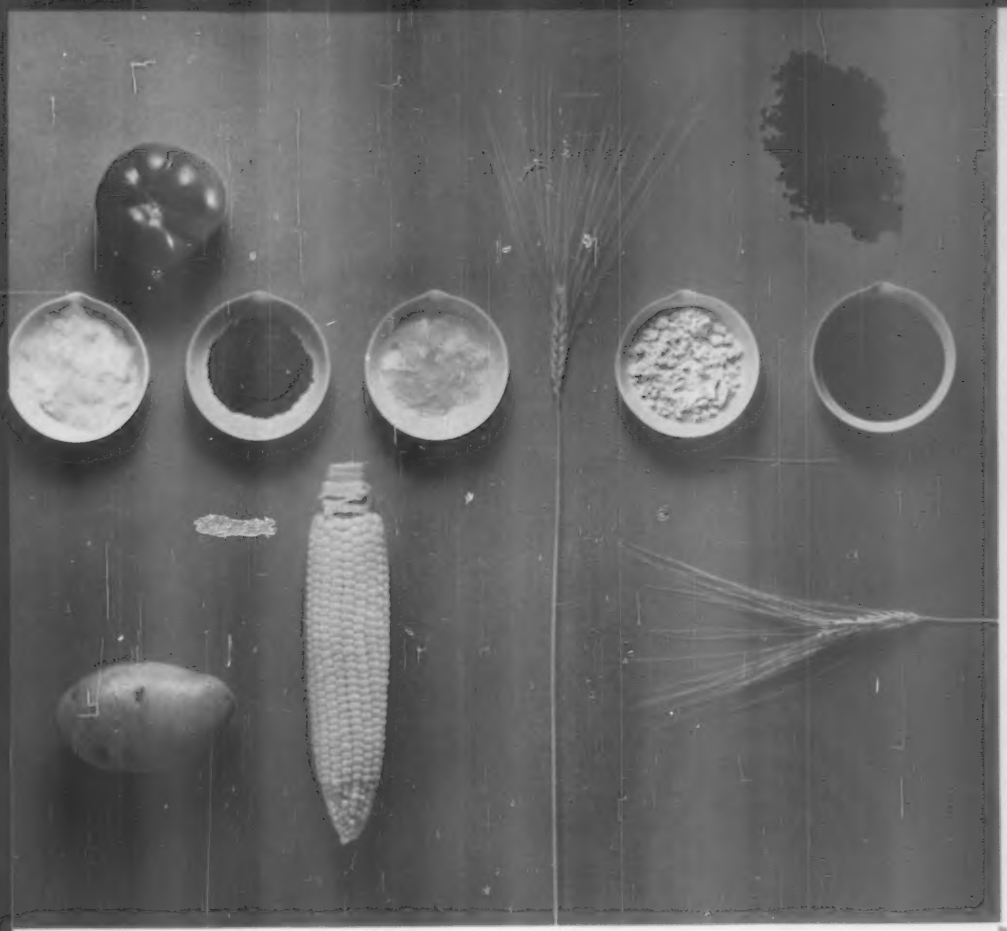
Qualities of beef as affected by cooking at very low temperatures for long periods of time. Vianna D. Bramblett, Robert L. Hostetler, Gladys E. Vail, and H. N. Draudt.

Although the method and length of time of cooking have been recognized for some time as influencing factors in the tenderness and juiciness of meat, there is little definite information as to whether changes occur in the connective tissue only or in the muscle fibers as well as in the connective tissue. This study was undertaken to determine the effect on less tender meat of cooking at very low oven temperatures for long periods of time. Three methods of evaluating tenderness were used, namely the tensile strength of muscle fibers, the Warner-Bratzler shear, and the taste panel. It is quite evident that the time-temperature combinations used in this study had an effect on the tenderness of the meat, probably causing both physical and chemical changes in the connective tissue and in the muscle fibers themselves. The findings suggest the possibility for further study to find conditions that would produce the desired softening in the connective tissue with the least change in the muscle fibers. (See page 707).

Measurement *Uniformity of color in green beans*

Uniformity of color measure in green beans. Edward Ross.

During an objective evaluation of green beans for processing, the authors noted the rapidity with which individual color measurements could be made with the Hunter Color and Color Difference meter. This experience suggested the practicability of a basic statistical approach to a uniformity measure. If enough individual color measurements are made, the bilateral distribution of these values from the mean color value should be a measure of degree of uni-



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Tomato Flakes
Dried from pure tomato paste containing no additives or stabilizers by a Buflovak dehydration technique. The new product has superior color, flavor, storage stability, and excellent reconstitutive properties.

Dry Corn Syrup
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Vital Wheat Gluten
A new one-step technique, using a Buflovak Spray Dryer, continuously produces a powdered product. The color, vitality, and high protein content are retained. Reconstituted gum gluten has excellent native quality.

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A continuous process, involving counter-current extraction, concentration, and instantaneous drying, was developed at Buflovak to improve this product. Color, aroma, solubility, and flavor assure a high quality convenience food.

Buflovak equipment shapes today's newest foods

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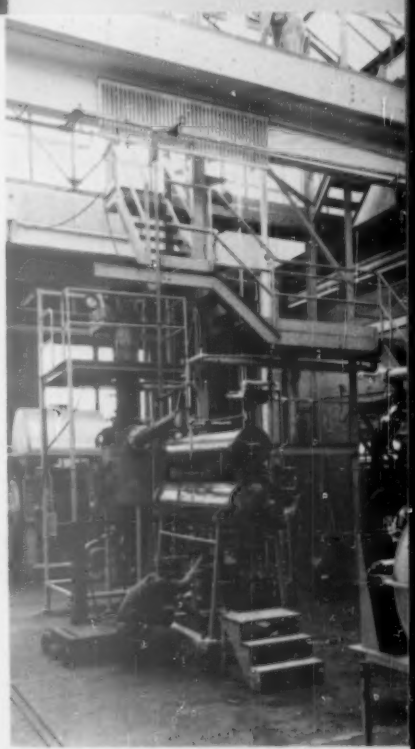
And Buflovak assures on-schedule delivery and continuing customer service to speed your production, increase your profits. Send for Catalog 386 "Buflovak Processing Equipment," Catalog 381 "Buflovak Customer Service Laboratory."



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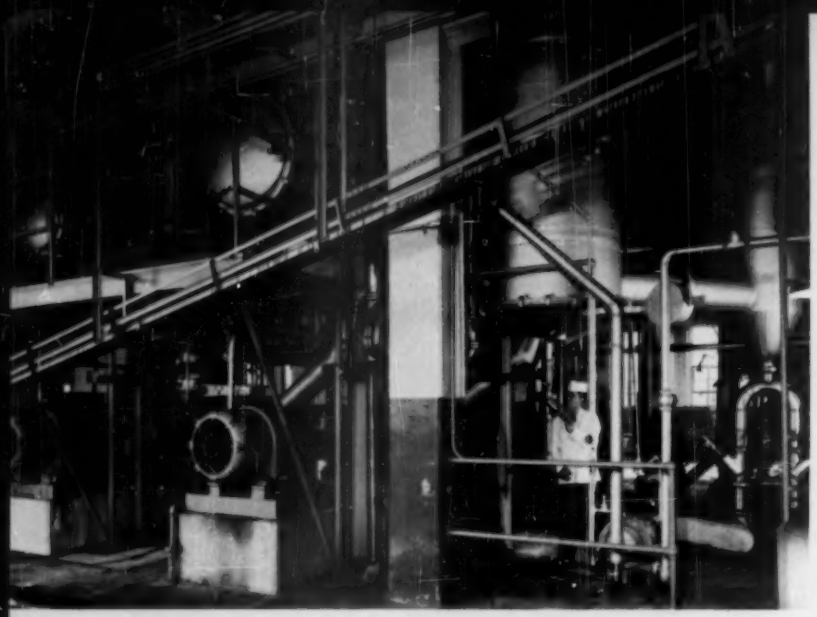
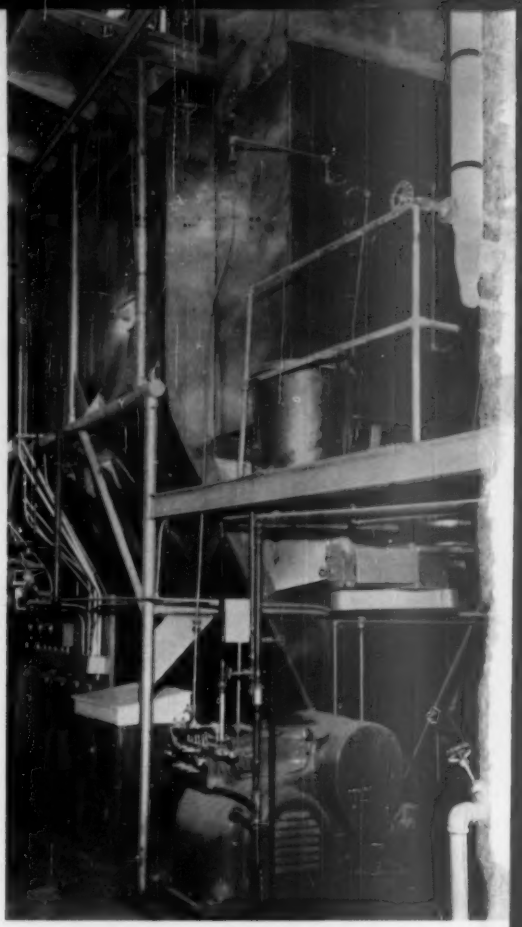
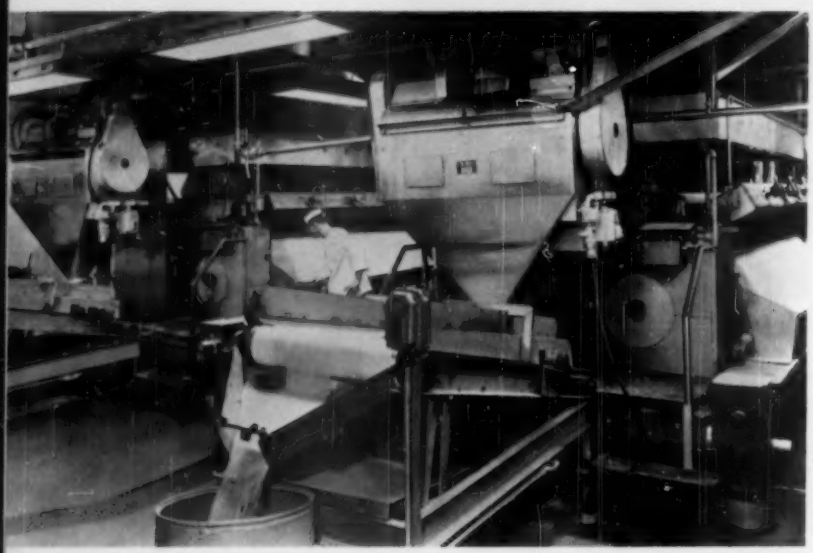


Triple-effect evaporator has increased tomato paste production over 100% at American Home Food's Oakland, California plant.



Spray Dryer is used by Mid-West Solvents at Atchison, Kansas to produce a superior grade of vital gluten used for food enrichment.



Drum Dryers produce 210,000 pounds of flaked cereal for Beech Nut's Rochester, New York plant. They work a 140-hour week, take just 4-hours to clean.

Buflovak engineers equipment to cut food processing costs

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formity. *One* value expressing the extent of this distribution is the mean square (variance, s^2) calculated from a number of individual color determinations. The square root of this is the standard deviation *(s)*; 68% of the values in the normal sample distribution are in the interval m ± *s*. The magnitude of *s* is a quantitative measure of the extent of color variability (disuniformity). To meet this need for a quantitative uniformity measure in grading and quality evaluation, a statistical "property" of a sample population was defined. The "property" was the average square of the deviation from the mean value for the quality factor under investigation. The measure was applied to color evaluation of processed Blue Lake beans for 3 seed strains and 4 picking times. Color was measured by the Hunter Color and Color Difference meter. Analysis of variance for the uniformity measure showed significant differences between strains and between picking times. Possible influences of bean size and processing treatments are discussed. Mean color values of uniformity samples are used to characterize the base, or overall, color. Effects of seed strain, picking time, size grade and processing treatment on this base color are reported. Limits for color variation in canned green beans, as specified by U. S. Department of Agriculture grade standards, are determined by simple statistical calculations based on objective color data obtained with an acceptable standard variety. An example of color uniformity grading by these limits is given. (See page 711.)

Moisture transfer formula — *Combinations of dehydrated foods*

Moisture transfer in combinations of dehydrated foods. Harold Salwin and Vida Slawson.

Among the newer military feeding concepts is the quick-serve meal. This meal is largely comprised of precooked dehydrated foods. The only field preparation required for these quick-serve meals is reconstitution with either hot or cold water. Components of these meals are in themselves stable but may have poor shelf life as a result of transfer of moisture to or from other components. Specifically, stability is impaired in mixtures of dehydrated foods in which there is a transfer of water from items of higher moisture-vapor pressure to those of lower moisture-vapor pressure. Isotherms which show the relationships between moisture content and vapor pressure (or relative humidity) of the components of a food mixture provide guidance as to their packaging compatibility. A formula is presented for computing from the isotherms the equilibrium relative humidity of such mixtures and the final equilibrium moisture content of each component. Data are presented which show the close agreement between final moisture contents calculated by the formula and values determined experimentally. (See page 715.)

Enzymatic browning — *Apple tissue*

Effect of borates and other inhibitors on enzymatic browning in apple tissue. Karakian Bedrosian, A. I. Nelson, and M. P. Steinberg.

Many fruits and vegetables are susceptible to rapid discoloration following mechanical or physiological injury. The reaction responsible for this is an enzyme-catalyzed oxidation of phenolic compounds. The purpose of this study was to investigate the properties of boric acid and borate salts as inhibitors of enzymatic browning of apple tissue. Boric acid and borate salts are, of course, not presently approved for use by the Food and Drug Administration. However, the inhibition of enzymatic browning by masking the oxidation site is of interest regardless of the immediate applicability of the particular complexing agent being used. Sodium meta- and tetra-borate (STB) were found to be effective inhibitors of enzymatic browning, whereas sodium perborate and boric acid were not effective. Borate activity was not affected by pH. Study of STB with other inhibitors for apple slice browning indicated favorable interaction of STB with sodium diphosphate, ascorbic acid, sodium chloride, sucrose and sodium bisulfite. Optimum pH range for interaction of ascorbic acid and STB was 5–7. Both sucrose and dextrose were found to be equally effective as browning inhibitors. Activity of sodium bisulfite varied with pH, the optimum being in the acid range. STB was found to exert no detrimental effect on flavor, texture, or off-flavor. The general acceptability study further showed that 0.5% STB plus 100 p.p.m. SO_2 from sodium bisulfite gave uniformly excellent color protection during the 14-day storage period. The sulfite alone gave fair protection; the combination of STB with ascorbic acid yielded samples slightly below acceptable; and the ascorbic acid alone gave hardly any protection at all. (See page 722.)

Flavor technology — *Canned Bartlett pears*

Sweetness and acidity adjustment in canned Bartlett pears. Marion Simone, L. L. Claypool, S. J. Leonard, and B. S. Luh.

Sweetness and acidity are important components of flavor in fruit products. This paper illustrates the effect of syrup

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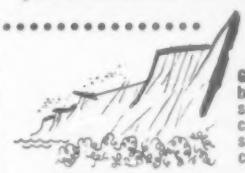

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adjustment with varying sucrose or citric acid content on the flavor of canned Bartlett pears. In California, Bartlett pears for canning are grown in 3 different areas with regards to geological and climatic conditions. These environmental variables result in differences in chemical composition of the fruit and have an important effect on the flavor quality of the canned product. Total acidity and/or soluble solids content of the canned fruit have been adjusted at the time of processing to increase the acceptability of those fruits which have been grown in areas which affect low acid and/or low sweetness level naturally. (See page 727.)

Method for determining lead number — *Vanilla extract*

Vanilla extract: An improved lead number determination. William J. Considine.

A volumetric method for the determination of the lead number of vanilla extract is described. The sample is prepared according to the usual method of Wichmann and lead is determined by titration with ethylenediaminetetraacetic acid. (See page 730.)

Legislation — *Inspection Act, poultry*

Development of the Poultry Products Inspection Act. Frank G. Wollney.

Pubic Law 85-172, the Poultry Products Inspection Act passed by the 85th Congress and made effective May 1, 1958, represents a constructive effort. The Act gives the Secretary of Agriculture full authority to require post mortem inspection when he deems it essential to the production of wholesome poultry products. This paper presents a brief progress report on the Act, describing how the poultry industry has moved into the program and achieved a relatively smooth transition from non-inspected to inspected operations. Among the by-products of the Act is an increased demand for food technologists. (See page 731.)

Glossary — *Terms used in sensory testing*

Glossary of some terms used in the sensory (panel) evaluation of foods and beverages. Committee on taste testing (1958).

The first objective of the committee was "to bring order out of chaos in this field where empiricism is rampant, definitions and terminology need to be established, methodology screened, evaluated and developed, and results of such tests interpreted in significant terms." The committee therefore undertook to develop a glossary of terms. The final list, agreed upon by the entire committee following considerable correspondence and oral discussions during 1958 and 1959 consists of 85 terms. In making the final decisions for including and defining the terms, the committee was guided by the extent to which a term is used specifically in sensory testing. Only a minimum of terms which are basically psychological or statistical in nature, are included. This glossary is intended as (1) a guide to students and investigators beginning work in this field; (2) an authoritative reference whereby different workers in the field may speak the same language. (See page 733.)

Of Professional Interest

AWARDS

The Babcock-Hart Award

DONOR: The Nutrition Foundation, Inc.

AWARD: $1,000.00 and an engrossed plaque.

PURPOSE: To honor a person who has distinguished himself or herself by contributions to Food Technology which have resulted in improved public health through some aspect of nutrition or more nutritious food.

NOMINATIONS: Nominations may be made by any member of the Institute of Food Technologists. Nominations shall be in letter form giving a biographical sketch of the nominee and detailing the contributions that would qualify the individual for the award. Nominating letters shall be limited to two, single-spaced, typewritten sheets. This Award can be made only for technological developments or scientific contributions which lead directly to technological developments. January 1st is the deadline for receiving nominations. Address letter to the Secretary, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Illinois.

The Nicholas Appert Award

DONOR: The Institute of Food Technologists.

AWARD: This Award, originated by the Chicago Section of the Institute of Food Technologists, consists of a Bronze Medal (furnished by the Chicago Section) and an honorarium of $1,000.00.

PURPOSE: To honor a person for pre-eminence in and contributions to the field of Food Technology.

NOMINATIONS: Nominations may be made to the Executive Secretary by any member of the Institute of Food Technologists. Nominations shall be in letter form giving a biographical sketch of the nominee and detailing the contributions that would qualify the individual for the award. Nominating letters shall be limited to two, single-spaced, typewritten sheets. January 1st is the deadline for receiving nominations. Address letter to the Secretary, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Illinois.

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STALEY'S Soy Flour and Grits	High-protein food ingredient binder offering decided advantages in palatability, nutrition, smoothness, prolonged shelf life.	Enhances flavor, increases nutritional values. Supplies significant amounts of vitamins, minerals, amino acids. Absorbs and retains moisture.	Extensively used in bakery goods; sausage; loaf goods; chili con carne; scrapple; dog food; dehydrated soups.
ZEST* Monosodium Glutamate	A low-cost way to bring out the natural goodness in foods without adding flavor or aroma of its own. 99+% pure.	For a fraction of a cent a pound, Zest gives your products a competitive advantage without any change in formula.	Most sausages; meat loaves; bacon; canned meats; stews; soups; poultry; gravies; frozen meat products; canned and frozen vegetables.
STALEY'S Hydrolyzed Vegetable Protein	A concentrated source of flavor made from corn protein. Being stronger and more distinctive in taste, less is needed.	Boosts natural meat flavor. Imparts appetizing golden-brown color at proved reductions in cost.	Stews; frozen meat pies; meat loaves; chili con carne; corn beef and roast beef hash; table sauces; dog food.

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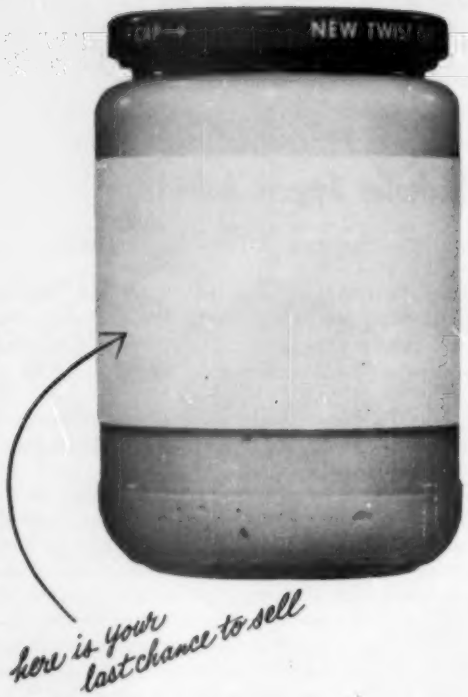

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FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1959-1960	
December 26-31	The 126th Meeting of the American Association for the Advancement of Science, Morrison Hotel, Chicago
December 26-January 3	Dairy and Food Exposition, New York Coliseum, New York, N. Y.
January 17-20	Canners Convention and Show, Americana Hotel, Bal Harbour, Florida
January 18-20	National Canners Association 53rd Annual Convention, Miami Beach, Florida
February 11-13	National Food Conference, Palmer House, Chicago, Illinois
February 12-14	Fact Finding Conference, Institute of American Poultry Industries, Kansas City, Missouri
February 23-24	Eighth Annual National Dairy Engineering Conference, Kellogg Center, Michigan State University, East Lansing, Michigan
March 3-4	Second Better Foods for Better Nutrition Conference, Center for Continuing Education, University of Georgia, Athens, Georgia
March 11-12	Eighth Annual Food Technology Short Course, "Impact of Convenience Foods," Memorial Student Union, University of Missouri. Sponsored jointly by the St. Louis and Kansas City Sections of IFT with the College of Agriculture, Columbia, Missouri
April 19-21	Research and Development Associates 14th Annual Meeting, Congress Hotel, Chicago, Illinois
1960	
May 15-19	**Twentieth Annual Meeting of the Institute of Food Technologists, Fairmont Hotel and Masonic Temple, San Francisco, California**
May 19 to May 25 or 29	**IFT Pacific Rim Conference, Princess Kaiulani Hotel, Honolulu, Hawaii**
1961	
May 7-11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 17-20	**Twenty-second Annual Meeting of the Institute of Food Technologists, Americana Hotel, Bal Harbour, Miami Beach, Florida**

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

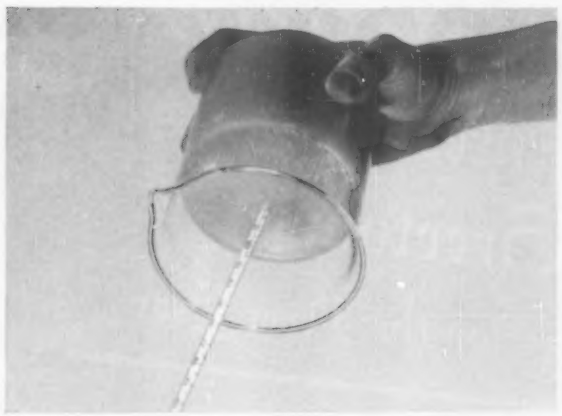
REGIONAL NEWS

ST. LOUIS

"Impact of Convenience Foods" is to be the subject of the Eighth Annual Food Technology Short Course, March 11–12, 1960. The short course is jointly sponsored by the St. Louis and Kansas City Sections and the College of Agriculture, the University of Missouri, Columbia, Mo.

Dr. Owen Cotterill, Poultry Husbandry Department, College of Agriculture, University of Missouri, is Program Chairman for the short course. It will be held at the Memorial Student Union Building on the University Campus at Columbia, Mo. The short course will again be in the form of a two day panel discussion meeting. The Friday morning (March 11,

(Continued on page 18 following technical section)



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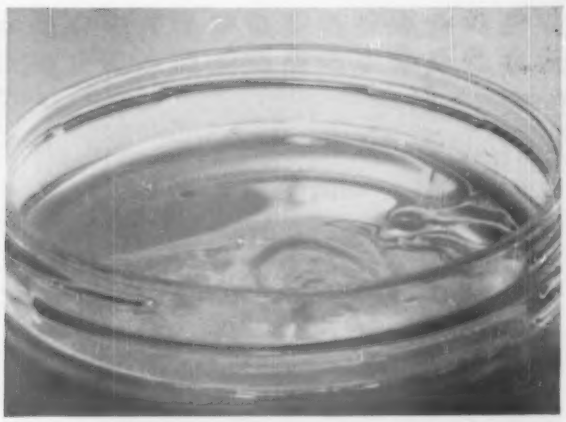

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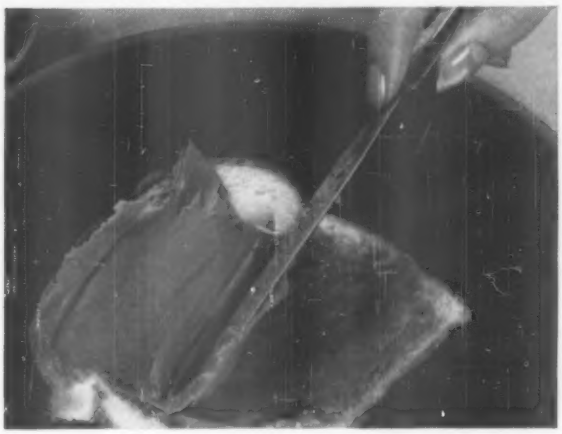

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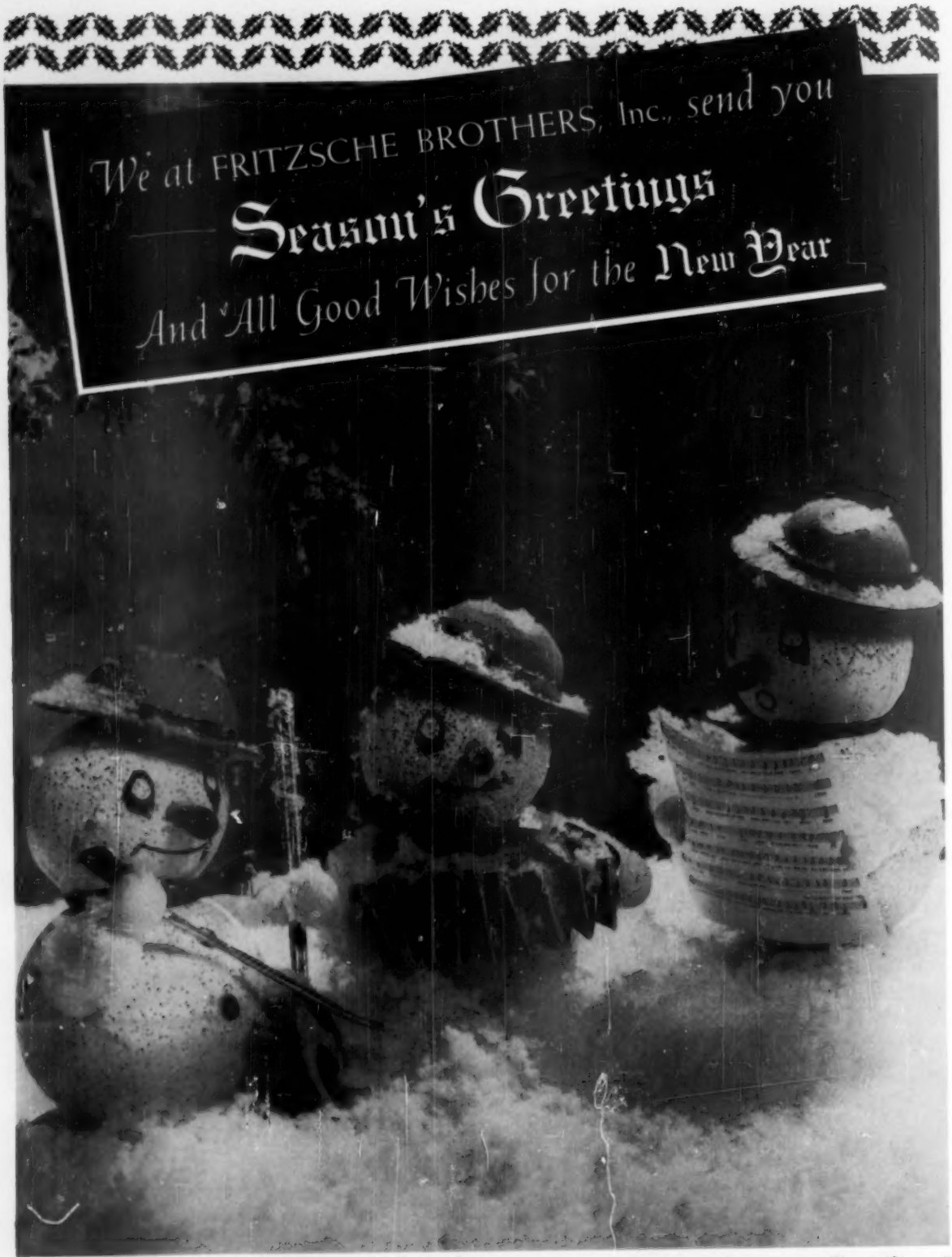
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A Rapid Method for Production of a Sparkling Apple Wine[a, b]

F. E. Atkinson, J. F. Bowen, and D. R. MacGregor

Fruit and Vegetable Procesing Laboratory, Research Station, Summerland, B. C., Canada Department of Agriculture

(Manuscript received June 22, 1959)

Apple growers in North America are faced with a continuing problem of finding a remunerative outlet for commercial grade fruit not suitable for sale on the fresh market. In Europe a good proportion of the apple crop is manufactured into apple wine (hereafter called cider). However, this fruit is of specific cider varieties not normally used for culinary purposes. On this continent fermented cider has been produced commercially to a very limited extent and cider varieties are not grown; consequently, the North American processor wishing to use cider as an outlet for surplus apples is faced with the problem of manufacturing a palatable product from what are normally dessert varieties. A companion article reports results of work on maturity of apples and blending of varieties to develop a suitable beverage from these North American varieties *(3)*.

A brief review of cider types and manufacturing methods in Europe reveals that they differ considerably from one country to another. For example, the Swiss prefer a dry cider containing 0.6% acid or more and about 1% sugar. The raw material for this cider may be fresh juice or concentrate. Germany also seems to prefer a dry, acid type of drink. In France, on the other hand, the majority of cider appears to be of a low acid type. English ciders vary considerably depending upon place of manufacture and local taste. However, a moderately sweet, sparkling cider of relatively low alcohol content has recently become very popular. It is manufactured by large commercial concerns (unpublished observations). Sparkling cider is prepared either by the champagne process or by artificial carbonation, or a combination of both in the Charmat Closed Cuvée method *(8)*. In America, Tressler *et al. (7)* describe a method for the production of sparkling cider utilizing a secondary fermentation in cuvée. The secondary fermentation required 3 to 4 days at a temperature of 70° F. (21.1° C.). Raw materials for this secondary fermentation were dry cider, apple concentrate, apple juice, sugar, ammonium phosphate, tannic acid, and the yeast starter.

The temperature at which cider fermentation should be carried out has given rise to considerable dissension. It has been stated *(4)* that for French cider a slow fermentation at a low temperature is necessary for a high quality product, and that the temperature should never be allowed to rise above 41° F. (5° C.). However, these conditions apply primarily to ciders made from the French type of bitter-sweet cider apple. In Germany, pure yeast cultures are used rather than allowing a natural fermentation to take place. A temperature of 59° F.–64.4° F. (15° C.–18° C.) is found to give a satisfactory product which has more of a wine character than the French or English ciders.

The manufacture of cider from Canadian apples has been described by Arengo-Jones *(1)*. Methods for the production of low alcohol ciders—sparkling, champagne, dry and carbonated—are outlined. Carbonated dry cider was improved by sweetening to 4% sugar.

In the present work the objective was to produce a palatable type of sparkling cider from the low-tannin varieties of apples grown in British Columbia. The original work on cider production in this laboratory had been aimed toward a product which could be packaged in cans and which therefore could not contain sulphur dioxide. However, it was found that without SO_2 a dark colored product was produced. The flavor varied from batch to batch. As the objective of this investigation was to produce a light colored, light flavored, sparkling drink, the addition of SO_2 was necessary to enable the manufacture of a cider of uniform character, and to maintain the most desirable features of the juice from which the cider was made. The work described here will cover the period after the decision to use SO_2 was made.

EXPERIMENTAL

The following factors were investigated in developing a process which would give a satisfactory product. Chemical analyses were performed using the methods described by Ruck *(5)*:

1. Sulphur dioxide concentration
2. Yeast strains
3. Fermentation temperatures
4. Sugar, acid and alcohol content
5. Containers

Sulphur dioxide. Sulphur dioxide in this cider serves two purposes. First, it provides a "clean" fermentation, and second, if it is added soon enough, it will prevent or reverse enzymatic browning of the juice. Preliminary tests showed that 100 p.p.m. of SO_2 prevented oxidation and controlled undesirable organisms. Since the pH of the juice normally used ranges from 3.3 to 3.8 *(6)* this level agrees with the recommendation of Beech *(2)*.

Yeast selection. In the search for a yeast which would give a clean tasting beverage with a minimum of yeast flavor and a maximum fermentation rate, 18 strains of wine and beer yeasts were investigated. In preliminary studies a "Tokay" wine yeast proved superior to two "Sauterne" yeasts, an Aus-

[a] Contribution No. 19, Research Station, Canada Department of Agriculture, Summerland, B. C.

[b] Presented at the Nineteenth Annual Meeting of the IFT, Philadelphia, Pennsylvania, May 18, 1959.

tralian wine yeast, and an isolate from an English cider. Selection was made by inoculating identical lots of cider stock with the yeast under investigation and checking for rapidity of fermentation and for flavor in the finished cider. The Tokay yeast strain tended to give a slight "yeasty" flavor to the cider. In an attempt to eliminate this flavor, 12 single colony isolates from a commercial lager beer starter and a culture of an ale yeast were compared. One lager isolate was superior in flavor to the "Tokay" and about equal in fermentation rate. The others were unsatisfactory as to fermentation rate, flavor, or both. The lager strain was chosen for further experimental work *(3)* and for commercial production of cider.

Fermentation temperature. The effect of temperature on the cider fermentation involves two factors; first, the rate of fermentation, and second the effect on the final flavor of the product. These points were checked by inoculating a standard cider stock of 16% total soluble solids and 100 p.p.m. SO_2 with 1% of an active yeast culture. This stock was then split into 5 portions and incubated at 95° F. (35° C.), 85° F. (29.5° C.), 77° F. (25° C.), 68° F. (20° C. and 55° F. (12.8° C.). It had been hoped that the 95° F. (35° C.) temperature would be sufficient to suppress fermentation entirely but, as shown in Figure 1, fermentation to 8.2% total soluble solids was accomplished in 3.5 days. Essentially the same time was required at 85° F. (29.5° C.), while 7 days were required at 77° F. (25° C.), 12 days at 68° F. (20° C.) and over 20 days at 55° F. (12.8° C.). Laboratory fermentations were conducted at 77° F. (25° C.) to avoid any possibility of a "stuck" fermentation and to enable more precise control of the end point.

Organoleptic tests of the finshed ciders fermented at the different temperatures showed no significant difference between any of the samples. Fermentation temperature therefore does not appear to be an important factor in the flavor of these ciders.

Sugar, acid, and alcohol content. At the beginning of this work it was decided that the most desirable alcohol content would be 5–7% by volume. The average sugar content of unsweetened apple juice is about 12.0% which would require fermentation to complete dryness to obtain the desired alcohol. However, in cider fermented to dryness an unpleasant bitter flavor has been encountered. This flavor can be eliminated by increasing the sugar content with sucrose or apple juice concentrate so that the fermentation can be stopped before it is complete.

In preliminary experiments a cider stock was used which was made up of apple juice with concentrate or sucrose added to give a refractometer reading of 19% total soluble solids. This soluble solids concentration produced a cider of undesirable sweetness. To overcome this the soluble solids in the cider stock was lowered to 16% giving a final sugar of 3.75–4.50%, which with 0.4% acid as malic resulted in a well balanced drink. Use of apple concentrate for fortification of the stock was discontinued when it was found that this material gave an undesirable "cloying" quality to the final product. Sucrose did not exhibit this property and proved most satisfactory in the production of a clean flavored beverage with a desirable sugar/acid ratio.

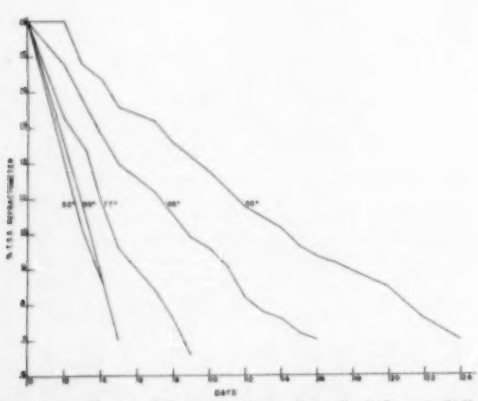

Figure 1. Rate of fermentation of apple juice at different temperatures ° F.

Containers. Twelve ounce beer bottles and 28 ounce soft drink bottles have been used. Aluminum spotted caps are not satisfactory because of excessive corrosion. Vinyl spotted caps have proved very satisfactory. After bottling the product is pasteurized by heating to 150° F. (65.6° C.) and then cooled.

LABORATORY PROCESS

Cider manufacture in the laboratory commences with the comminution of the apples in a hammer mill. Immediately after milling the pulp is pressed in a hydraulic press and the juice collected in a stainless steel pail. To each gallon of juice 0.9 g. of potassium metabisulphite ($K_2S_2O_5$) is added. This gives close to 100 p.p.m. of actual SO_2. No more than 4 minutes are allowed to elapse between milling and the addition of metabisulphite. This treatment restores the juice to its original color. The collected juice is treated with 0.1% of a commercial pectinase (Pectinol D), allowed to stand, and clarified by filtration. The juice is brought up to 16% total soluble solids with commercial sucrose, placed in a 5-gallon glass carboy and inoculated with 1–2% of a selected pure culture of *Saccharomyces cerevisiae*. Fermentation is allowed to proceed at 77° F. (25° C.) until a refractometer reading of 8.2% total soluble solids is obtained. At this point the carboy is stored at 40° F. (4.4° C.) or less to await filtration. This waiting period must not be more than one or two days since fermentation will continue to lower the solids reading about 0.1% per day. The fermented cider is filtered with suction through a bed of commercial filter aid. It is then carbonated in a sealed tank under 35 p.s.i. pressure overnight at 32° F. (0° C.) filled into bottles (usually 12 oz.) and crown capped.

COMMERCIAL PROCESS

On the basis of the laboratory work a schedule for manufacture of the commercial product has been set up. The recommended commercial process is as follows:

1. Select reasonably sound apples free from rot and mold.
2. Wash.
3. Grind.
4. Add sulphur dioxide. In practice 2% sulphur dioxide solution is metered into the pump which delivers the pulp to the hoppers over the presses. With the volume of fruit handled approximately 48 oz. of SO_2 solution per minute is required to give 100 p.p.m. residual SO_2 in the juice.
5. Press and screen on vibrating screen to remove coarse particles.
6. Check SO_2 level and adjust if necessary.
7. Heat to 70° F.–95° F. (21.1° C.–40.5° C.) and add pectinase. Agitate thoroughly after 1 hour and allow to settle about 1 hour.
8. Rough filter.
9. Make up to 16% total soluble solids by refractometer with sucrose.

10. Inoculate with 1–3% of active yeast starter grown in cider stock.

11. Ferment at 77° F. (25° C.) until a refractometer reading of about 8.9% is obtained and turn on cooling coils in fermenter so that fermentation stops at 8.2%. The complete process normally takes about 4 days. Chill to 29° F. (−1.7° C.).

12. Polish filter.

13. Carbonate at about 35 lbs. pressure and store in bottling tank under refrigeration at 29° F.–32° F. (−1.7° C.–0° C.).

14. Fill bottles and close.

15. Pasteurize to obtain a bottle centre temperature of 145° F.–150° F. (62.8° C.–65.6° C.) and cool as quickly as possible.

16. Store in cool storage, until used.

A schematic illustration of the process is illustrated in Figure 2. The complete process from pressing to bottling can be completed in one week. Approximately 4,000,000 bottles have been packed in 1958 and 1959 using this process.

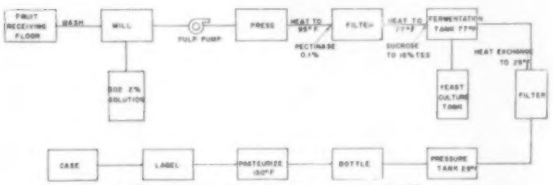

Figure 2. Flow diagram for commercial cider process.

Acknowledgment

The authors are indebted to Sun-Rype Products Limited, Kelowna, B. C. for co-operation in the use of their equipment and their contributions of raw materials.

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Effect of Fruit Variety and Maturity on Quality of Apple Wine[a, b]

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(Manuscript received June 22, 1959)

A CLASSIFICATION of apple varieties for the manufacture of fermented apple wine[c] defines four groups according to the concentration of "tannin" and acid in the fruit *(4)*. A "sweet" variety is one containing less than 0.2% tannin and less than 0.45% of titratable acid axpressed as malic acid. A "bitter sweet" variety contains more than 0.2% tannin and less than 0.45% acid. In the "sharp" classification, less than 0.2% tannin and more than 0.45% acid are present. The "bitter sharp" class contains 0.2% or more of tannin and 0.45% or more of acid.

Dessert apples grown in the Okanagan area of British Columbia fall into the "sweet" or "sharp" classification only. Owing to their low tannin content, none can be classed as "bitter sweet" or "bitter sharp" *(6)*. Important varieties in the "sweet" classification are Delicious and Spartan. "Sharp" varieties include Jonathan, McIntosh, Newtown, Rome Beauty, Stayman Winesap, and Winesap. Extended storage, however, may reduce the acidity of Rome Beauty and Stayman to the point where they fall into the sweet classification.

Ciders have been made by the English process at the Long Ashton Research Station, Bristol, England from a number of apple varieties grown in British Columbia *(3)*. These were evaluated as shown in Table 1.

TABLE 1

Quality of cider made from B.C. apples by the Long Ashton process. Long Ashton 1931

Variety	Comments
McIntosh	Sweet, fruity, pleasant flavor
Rome Beauty	Quite fair flavor; more character than McIntosh
Jonathan	Very fair cider. Pleasant brisk flavor
Delicious	Quite fair cider but too sweet
Stayman Winesap	Pleasant flavor. More body than rest of series
Newtown	Quite fair. Brisk flavor
Winesap	Not very good cider

The general opinion expressed by the Long Ashton Station was that these ciders were lacking in body as compared with ciders from English varieties. This was probably due to the low tannin content of the apples used.

[a] Contribution No. 18, Research Station, Fruit and Vegetable Processing Laboratory.

[b] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pa., May 18, 1959.

[c] This product resembles English cider and will be called "cider" throughout the remainder of this paper.

EXPERIMENTAL

Ciders were prepared during the 1958 season from the 7 varieties listed in Table 1, using the process developed at this laboratory *(2)*.

To determine the effect of fruit ripeness on cider quality, fruit was picked at optimum storage maturity (firm ripe) and stored at 70° F. (21.1° C.), an accepted temperature for ripening. Cider was processed from the fruit immediately after picking, and at intervals during storage life. In addition, cider was made from fruit ripened on the tree beyond normal picking maturity. Windfallen fruit of the McIntosh, Jonathan and Delicious varieties was also processed into cider.

Since McIntosh and Jonathan fruit tended to deteriorate rapidly at 70° F. (21.1° C.), it was necessary to process these varieties after periods of storage not exceeding 1 to 2 weeks. Delicious could be held for a longer period, cider being made after 2 and 3 weeks storage at 70° F. (21.1° C.). Newtown, Stayman, Rome Beauty and Winesap were processed into cider after 2 and 4 weeks storage at this temperature.

In the case of tree ripened fruit, McIntosh and Jonathan were left on the tree for one week after normal picking maturity, Delicious were picked 3 weeks late and Newtown, Stayman, Rome Beauty and Winesap 12 days late. Variations in the length of the period of tree ripening were necessitated by the characteristics of the individual varieties.

Windfallen McIntosh fruit was collected one week after normal picking maturity. Jonathan windfalls were collected 3 weeks after the normal picking date, and Delicious 4 weeks beyond the firm ripe stage.

At the time of pressing, samples of juice were collected and stored at −20° F. (28.9° C.) for further analysis. Values for pH, titratable acidity (as malic acid), total soluble solids by refractometer, total sugar, sulphur dioxide, and "tannin" were determined on the unfermented juice. Determinations of pH, titratable acidity, total soluble solids by refractometer, extract, total sugar, sulphur dioxide, and alcohol were carried out on the completed cider *(5)*.

To assess the quality of the ciders a 50-point score sheet was designed. Factors considered in rating a sample of cider were: aroma, color, sugar-acid balance, and flavor. Five points were assigned to color, 5 to aroma, 20 to sugar-acid balance, and 20 to flavor. A previously scored cider of high quality was used as a reference standard.

RESULTS AND DISCUSSION

Flavor Evaluation of Ciders

McIntosh. Ciders prepared from the McIntosh variety had a good balance of acid to sugar but unfortunately possessed, in all cases, an aromatic flavor described as "seedy" or "resembling bees wax." This flavor was encountered in varying intensities, but could not be correlated with maturity of the fruit. A "fruity" or "perfumed" flavor described by Arengo-Jones *(1)* and by Grove *(3)* in ciders from McIntosh may be identical with this flavor. Arengo-Jones *(1)* considered this flavor too strong to permit use of McIntosh alone and recommended that not over 25% of McIntosh be used in blended ciders.

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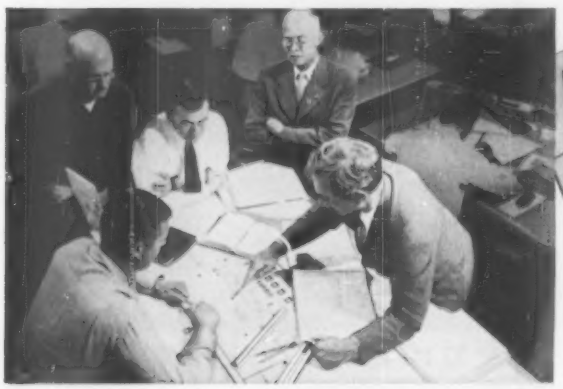

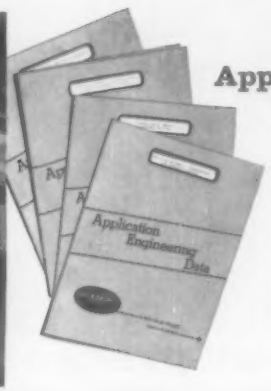

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Jonathan. Jonathan ciders had a tart, clean, refreshing flavor. Cider prepared from fruit picked at optimum maturity and processed immediately or stored for periods up to 2 weeks at 70° F. (21.1° C.) was superior to that made from fruit stored for a longer period at this temperature. Undesirable flavors were encountered in ciders made from Jonathan held more than 2 weeks at 70° F. (21.1° C.). This was not unexpected in view of the high percentage of rot and surface scalding in this fruit. Fruit left on the tree for as long as 3 weeks beyond the normal picking date yielded good ciders of clean, acid flavor. At this stage, Jonathans were very firm, mellow in quality, and free from breakdown. However, when such fruit was stored at 70° F. (21.1° C.) it deteriorated rapidly, showed extensive breakdown after one week, and imparted an unpleasant flavor to the cider.

Windfallen Jonathans although firm and of good appearance yielded a poorly flavored cider, with a strong "soapy" taste.

Delicious. In contrast to the Jonathan variety, Delicious gave ciders very low in acid, and of a bland flavor. Fruit at normal picking maturity yielded clean flavored ciders after periods of up to 3 weeks at 70° F. A desirable aromatic quality could be observed, increasing in intensity as the fruit became riper. After 3 weeks storage, the fruit was soft, with a high percentage of rot.

Fruit picked up to three weeks after the normal harvest date produced good cider. Cider from windfallen Delicious, however, was poor in quality with an oxidized, bitter flavor.

Rome Beauty. Rome Beauty fruit of normal picking maturity yielded cider with fairly good flavor and moderate acidity. Fruit allowed to remain on the tree for an additional 3 weeks gave cider of similar quality. In both cases, the fruit was very firm. Ciders made from Rome Beauty stored at 70° F. (21.1° C.) for 2 to 4 weeks had a bitter, unpleasant flavor. Rome Beauty stored for 2 weeks was quite firm, but after 4 weeks storage the fruit was very soft and over ripe.

Newtown. Only freshly picked "firm ripe" Newtown fruit yielded cider of acceptable quality. When fruit was stored at 70° F. (21.1° C.) for 2 to 4 weeks, or permitted to ripen on the tree for 2 weeks, an oxidized, bitter flavor developed in the cider. Ciders from this variety had a slightly acid flavor, excepting that made from tree ripened fruit which had a bland flavor. Newtowns stored for 2 weeks were quite firm, but after 4 weeks storage the flesh began to show a brown breakdown in the core area.

Winesap. Winesap ciders processed from freshly picked "firm ripe" fruit, tree ripened fruit, and from stored fruit all had an undesirable bitter flavor. The bitter flavor was most noticeable in cider made from stored fruit, less so in that made from freshly picked "firm ripe" or tree ripened fruit. Fruit stored at 70° F. (21.1° C.) for 2 weeks was quite firm, but after 4 weeks had begun to break down.

Stayman Winesap. Cider of fair quality and a desirable degree of acidity was made from freshly picked "firm ripe" Stayman Winesap. Fruit stored at 70° F. (21.1° C.) for 2 weeks gave cider with a definitely aromatic quality. After 4 weeks at this temperature the fruit yielded cider of good flavor, slightly superior to that made from fruit stored for 2 weeks. Tree ripening of the fruit resulted in a poor cider, with a bitter, oxidized flavor. Stayman Winesap remained firm and free from breakdown even after the 4 weeks storage period.

Analytical data. Chemical determinations carried out on freshly pressed juices and on the corresponding finished ciders did not show a consistent relationship between the composition of the fresh juice and the quality of the finished product.

However, the results did indicate that total titratable acidity of the juice decreased with length of storage of the fruit, a fact which is of considerable value in producing a desired cider blend. Also, the data showed Delicious to be at the low end of the acid scale, with McIntosh, Newtown, Rome Beauty, Winesap and Stayman intermediate in acidity, and Jonathan of high acid content.

Values obtained for "tannins" in the fresh juice confirmed observations made by Grove *(3)* and Strachan *et al. (6)* that these varieties are very low in "tannin" as compared with English cider varieties, which range from 0.1% to as high as 0.4% "tannin."

Average values are given in Tables 2 and 3 for results of analyses of fresh juices and of the corresponding completed ciders processed during the 1958 season. Table 4 gives the average composition of fresh fruit over the period 1943–49 *(6)*.

Blending of Ciders

A study made at this laboratory has indicated that the most desirable ciders are those containing 8.2%

TABLE 2

Average composition of apple juices used for cider, 1958

Variety	pH	Titratable acid	Total soluble solids*	Tannin	Total sugar
		%	%	%	%
McIntosh	3.53	0.52	11.0	0.050	10.2
Jonathan	3.45	0.71	11.9	0.045	11.1
Delicious	3.82	0.21	10.9	0.042	10.5
Rome Beauty	3.55	0.47	12.2	0.052	11.7
Newtown	3.52	0.55	12.8	0.055	12.4
Winesap	3.58	0.49	12.5	0.044	11.9
Stayman Winesap	3.56	0.39	12.2	0.050	11.3

* By refractometer.

TABLE 3

Average composition of cider 1958

Variety	pH	Titratable acid	Total soluble solids*	Total sugar	Extract	Alcohol
		%	%	%	%	%
McIntosh	3.59	0.58	8.9	4.9	6.6	4.9
Jonathan	3.61	0.69	8.7	4.8	6.5	4.8
Delicious	3.77	0.40	8.5	4.8	6.1	4.8
Rome Beauty	3.82	0.49	8.9	4.3	5.9	4.3
Newtown	3.78	0.55	8.4	4.2	5.9	4.2
Winesap	3.85	0.45	8.3	4.2	6.4	4.2
Stayman Winesap	3.87	0.57	8.6	4.3	6.4	4.3

* By refractometer.

TABLE 4

Average composition of British Columbia apple juices 1943-49 inclusive

Variety	pH	Tit atable acid	Total soluble solids*	Tannin	Total sugar
		%	%	%	%
McIntosh	3.34	0.54	12.7	0.038	10.89
Jonathan	3.33	0.64	13.6	0.023	11.45
Delicious	3.90	0.27	13.2	0.023	11.79
Rome Beauty	3.40	0.55	13.6	0.041	11.54
Newtown	3.30	0.61	13.8	0.017	11.67
Winesap	3.47	0.58	14.8	0.027	12.82
Stayman Winesap	3.37	0.59	13.8	0.024	11.69

* By refractometer.

total soluble solids by refractometer, 0.37 to 0.50% total acidity, expressed as malic acid, and having a pH value of 3.5–3.6. Blends of juices from the 7 varieties of apples listed in Table 1 were made so that these values were obtained in the finished cider. A total titratable acidity in the fresh juice, of approximately 0.4% as malic acid gave finished ciders of the desired degree of acidity.

Taste panel evaluation of a number of blends showed that a blend of 60% Delicious with 40% Jonathan gave cider of excellent quality when freshly picked fruit was used. As the fruit ripened in storage it was found necessary to change the proportions of the 2 varieties in order to maintain the desired degree of acidity. A blend of 50% Delicious with 50% Jonathan gave the required acid content in the cider when riper fruit was used.

It was found that a satisfactory cider could be obtained in blends by replacing Jonathan with later varieties such as Newtown, Stayman or Winesap in proportions which gave 50% Delicious and 50% of the other variety.

Ripe Rome Beauty, owing to its relatively low acid content, may be used in blends late in the processing season to replace Delicious, in the event that Delicious become over-ripe.

In commercial practice it was found necessary to maintain a constant check on the acidity of the blended juices and to change the proportion of Delicious to other varieties as the acidity decreased with advancing ripeness. By this means a cider of constant acid content was maintained.

In no case was it found possible to include McIntosh in the blend of juice for cider, because the aromatic flavor of this variety was considered quite unpleasant.

SUMMARY

Fermented apple ciders were prepared from seven apple varieties. Fruit freshly picked and fruit stored at 70° F. (21.1° C.) for varying periods was used. Considerable variation in quality of cider was observed. The most satisfactory ciders were those made from firm ripe fruit processed after a minimum storage period.

No consistent relationship was established between the flavor of ciders and the chemical composition of the original juice, other than acidity which served to determine the composition of cider blends throughout the season.

The most desirable ciders were composed of Delicious blended with Jonathan. Newtown, Winesap or Stayman Winesap could be substituted for Jonathan. In commercial production the proportion of Delicious in the blend was adjusted throughout the season so as to maintain a constant value for titratable acidity. Ripe Rome Beauty may be used to replace Delicious in blended cider.

McIntosh contributed an undesirable flavor and at present is considered unsuitable for processing into cider.

Acknowledgment

The authors are indebted to Messers. J. A. Kitson, A. W. Moyls and J. A. Ruck for their co-operation in performing analyses, and to Sun Rype Products Limited for supplying fruit used in this work.

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The Influence of High Temperature Holding Upon the Components of Coffee Brew. III.

Hydrogen Sulfide, Sulfur Dioxide, and Sulfhydryl Compounds (Mercaptans)[a, b]

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(Manuscript received May 21, 1959)

REPORTS OF sulfur-containing compounds in the chemical literature on coffee have raised interesting points of conjecture regarding their behavior under conditions normally associated with coffee manufacturing processes. The reported presence in coffee of some of these highly flavored, odorous substances leads to curiosity regarding the role that such compounds might play in coffee flavor.

There are many references in the literature describing the presence of sulfur-containing compounds in coffee *(1, 7, 8, 10, 11)*. Early investigators have reported the presence of such substances as hydrogen sulfide, methyl mercaptan, furfuryl mercaptan and dimethyl sulfide. Recently, Giral and Fernandez *(7)* reported the presence of furfuryl mercaptan and Hughes *(8)*, the presence of hydrogen sulfide in coffee. More recently, Barbera *(1)* reported the presence in coffee of the sulfur-containing amino acids cystine and methionine.

Hughes and Smith *(9)* found the concentration of hydrogen sulfide in coffee to be very small, only two to three parts per million. This amount, they reported, disappeared from their samples after standing. They found that hydrogen sulfide was produced upon brewing, reheating and boiling. Interestingly, Hughes and Smith have also reported that they were unable to detect the presence of mercaptans.

The increasing frequency of reports concerning sulfur-containing compounds in coffee, the paucity of information about the stability of these compounds in beverage at high temperature, the possible consequence of resultant changes on the organoleptic quality of the beverage, and some discrepancies noted in the literature, have prompted this investigation.

EXPERIMENTAL

Standard coffee brew (10) was prepared, according to the recommendations of the Coffee Brewing Institute (85 g. of drip ground coffee plus 1330 ml. of redistilled water).

Standard experimental conditions (11) were selected as follows: holding temperature of 63° C., 73° C., 83° C., and 93° C., and holding times of 0, 1, 3, 6, and 24 hours.

The blend composition of the coffee studied (11) here was 30% Santos (Brazil), 35% Armenia (Colombia), and 35% Mara (Venezuela).

Organoleptic evaluation data were taken from the study by Segall and Proctor *(11)*, which was carried out concurrently with the work on sulfur compounds.

Preparation of a standard hydrogen sulfide solution

Reagents:

0.1 N $Na_2S_2O_3$, 12.5 g. of $Na_2S_2O_3 \cdot 5H_2O$
500 ml. redistilled H_2O

0.1 N iodine solution
13.0 g. iodine
20.0 g. KI
1000 ml. redistilled H_2O

Starch indicator
500 ml. of boiling redistilled H_2O
5 g. soluble starch

H_2S solution
bubble pure H_2S through 500 ml. of redistilled H_2O for one minute.

20% zinc acetate solution

The H_2S concentration of the solution is determined by direct titration:

Procedure

1. Pipett 10 ml. of the H_2S solution into 10 ml. of 20% zinc acetate solution, in a 100 ml. volumetric flask, make to volume with redistilled H_2O, and set aside for the preparation of the Standard Curve.
2. To the remaining 490 ml. of H_2S solution, add 30.0 ml. of the standard 0.1 N iodine solution.
3. Back titrate the excess iodine with standard 0.1 N thiosulfate, using starch as the indicator.
4. From the factor, 1 ml. of standard 0.1 N iodine is equivalent to 1.7 mg. of H_2S, the H_2S concentration may be calculated.

Demonstration of the absorption spectrum of methylene blue and preparation of a standard curve for hydrogen sulfide determination

Reagents: Zinc acetate, 2% solution, C.P. in redistilled H_2O. N-N-dimethyl-p-phenylenediamine sulfate solution (p-aminodimethylaniline sulfate, Eastman) 1.0 mg. per ml. of 2 plus 1 H_2SO_4 (two parts acid to one part redistilled H_2O, cooled to room temperature).

Ferric chloride solution, 2.7 g. in 50 ml. of concentrated HCl, made up to 100 ml. with redistilled H_2O.

Procedure

1. 0, 1, 2, 3, 4, 5, 10, and 19 ml. aliquots of the previously prepared standard solution of H_2S in zinc acetate (step one of the *Preparation of a Standard Hydrogen Sulfide Solution*) are pipetted into 50 ml. volumetric flasks containing 25 ml. of 2% zinc acetate solution. This addition is carried out in an ice bath, at 10° C.

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[a] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, May 18, 1959.

[b] Contribution No. 375 from the Department of Food Technology, Massachusetts Institute of Technology.

[c] Director of Research, Kwik Kafe Coffee Processors of America, Inc., Hatboro, Pennsylvania.

2. Add 5 ml. of the N-N-dimethyl-p-phenylenediamine sulfate solution.
3. Add 1 ml. of the ferric chloride solution.
4. Make to volume with 2% zinc acetate solution and shake gently.
5. Allow to stand at room temperature for one hour.
6. The optical density is determined by placing an aliquot of the solution in a 1.0 cm. Corex glass cell and reading at 745 mμ. on a Beckman Model D.U. Spectrophotometer.

The optical density of one of the aliquot preparations of the standard H_2S solution is determined at several wave-lengths from 400 mμ. through 780 mμ. These optical densities are plotted against the wave-length to give a curve of the absorption spectrum of the methylene blue, formed from the reaction of H_2S and N-N-dimethyl-p-phenylenediamine sulfate. This curve shows the maximum absorption point to be at 745 mμ.

Plotting the optical density at 745 mμ against the known H_2S concentration of the standard H_2S solutions, gives the Standard Curve (Fig. 1).

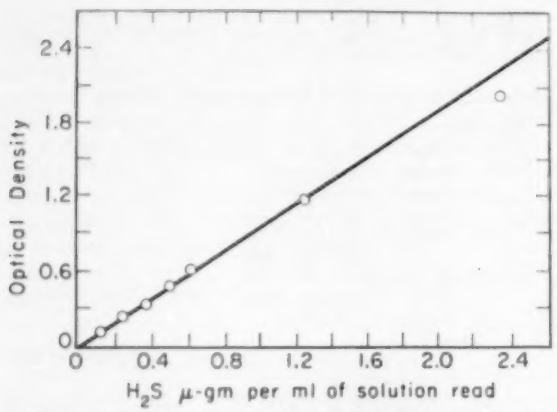

Figure 1. Standard curve H_2S concentration versus the optical density of the solution read.

Measurement of hydrogen sulfide in solution

Reagents: Zinc acetate, 20% C.P. in redistilled H_2O. Zinc acetate, 2% C.P. in redistilled H_2O plus 5 drops of glacial acetic acid per liter to prevent hydrolysis.

N-N-dimethyl-p-phenylenediamine sulfate, also called p-aminodimethylaniline sulfate, dissolve 1.000 g. of Eastman N-N-dimethyl-p-phenylenediamine sulfate in 2 plus 1 sulfuric acid (two parts of H_2SO_4 plus one part of redistilled H_2O, and cool to room temperature) to make one liter of solution. It can be stored under refrigeration for up to 2 months before it should be made fresh.

Ferric chloride solution, 2.7%, 2.7 g. of ferric chloride hexahydrate dissolved in 50 ml. of concentrated HCl, and diluted to 100 ml. with redistilled H_2O.

Hydrochloric acid, 1 plus 1, one part C.P. HCl plus one part redistilled H_2O, cool to room temperature.

Perforated glass bubbling tube, quarter inch o.d. glass tubing, 12 inches long, open at one end, sealed at the other and perforated with several one millimeter holes.

Aeration Flask, Lang-Farber, fitted with a frittered glass air inlet tube (Scientific Glass Apparatus Co., Inc., Bloomfield, New Jersey).

Procedure

1. Pour the solution (100 ml. of coffee brew) into a Lang-Farber Aeration Flask and insert the frittered glass air inlet tube.
2. Connect the inlet portion of the frittered glass air inlet tube to a tank of Prepurified Nitrogen by means of tygon tubing. The outlet portion of the Lang-Farber Aeration Flask is connected by tygon tubing to a perforated glass bubbling tube.
3. The "holed" end of the glass bubbling tube is immersed in 20 ml. of 2% zinc acetate solution in a graduated cylinder.
4. A volume of 1 plus 1 HCl, equal in quantity to the volume of solution (coffee brew) being used, is added into the Lang-Farber Aeration Flask. The flask is then sealed.
5. Prepurified nitrogen is then bubbled through the acidified solution (coffee brew) and thence the volatiles are carried through into the 2% zinc acetate solution. The rate of bubbling is moderate.
6. At the end of one hour, stop the flow of nitrogen and disconnect the gas bubbler from the Tygon tubing. Leave the gas bubbler in the graduated cylinder throughout the remainder of the procedure.
7. Cool the graduate cylinder in an ice bath to 10° C. or below.
8. Add 2.5 ml. of the N-N-dimethyl-p-phenylenediamine sulfate solution.
9. Add 0.5 ml. of the 2.7% ferric chloride solution.
10. Make to 25 ml. with 2% zinc acetate and mix well.
11. Allow to stand for one hour at room temperature.
12. The optical density is determined by placing an aliquot of the solution in 1.0 cm. Corex glass cells and reading at 745 mμ on a Beckman Model D.U. Spectrophotometer.

The hydrogen sulfide content is calculated as follows:

$$H_2S = \frac{(A)\quad(25)}{S}$$

A, the H_2S concentration per ml. of zinc acetate solution as obtained from the standard curve of optical Density at 745 mμ vs. concentration of hydrogen sulfide in μ-g. per ml. (p.p.m.)

S, ml. of standard coffee brew swept by the nitrogen.

Measurement of sulfur dioxide in solution

Reagents: Stannous chloride, dissolve 100 g. of stannous chloride dihydrate in 700 ml. of concentrated HCl and dilute to one liter with redistilled H_2O.

Buffer, dissolve 69 g. of sodium dihydrogen phosphate monohydrate in 750 ml. of distilled H_2O. Adjust to pH 7 with 20% NaOH and dilute to one liter with H_2O.

Zinc acetate, 2%, 20 g. of zinc acetate, C.P., in redistilled H_2O to make one liter. Add 5 drops of glacial acetic acid to prevent hydrolysis.

N-N-dimethyl-p-phenylenediamine sulfate, also called p-aminodimethylaniline sulfate, dissolve 1.000 g. of Eastman N-N-dimethyl-p-phenylenediamine sulfate in sufficient 2 plus 1 sulfuric acid (two parts concentrated H_2SO_4 plus one part redistilled H_2O, cooled to room temperature) to make one liter. Can be kept under refrigeration for 2 months.

Ferric chloride, 2.7%, dissolve 2.7 g. of ferric chloride hexahydrate in 50 ml. of concentrated HCl and dilute to 100 ml. with redistilled H_2O.

Procedure

1. Connect three 250 ml. glass-jointed Drechsel-type gas washing bottles in series with tygon tubing. The first bottle is connected to a tank of prepurified nitrogen. The last bottle is connected to the open end of a glass bubbler tube.
2. 100 ml. of the S_2Cl_2 solution is placed in each of the first 2 bottles. The third bottle is filled with 95 ml. of redistilled H_2O and 5 ml. of the buffer solution.
3. The "holed" end of the bubbler tube is immersed in 20 ml. of zinc acetate solution in a graduate cylinder.
4. 50 ml. of the solution under analysis (standard coffee brew) is added to the first bottle and nitrogen gas bubbled through the bottles for one hour at a moderate rate.
5. After one hour, the graduate cylinder is removed from the train and the nitrogen flow is stopped. The glass

bubbler is left in the graduate cylinder throughout the remainder of the procedure.

6. With the graduate cylinder in an ice bath (10° C. or less) add 2.5 ml. of N-N-dimethyl-p-phenylenediamine sulfate soluution.
7. Add 0.5 ml. of the ferric chloride solution and make up to 25 ml. with 2% zinc acetate.
8. Mix gently and allow to stand for one hour at room temperature.
9. The optical density of the solution is then obtained by placing an aliquot in a1.0 cm. Corex glass cell and reading at 745 mμ on a Beckman Model D.U. Spectrophotometer.

The H_2S obtained from this treatment of the sample is determined by reading off of the same standard curve as was used for the H_2S determination. The quantity of SO_2 is calculated from this H_2S by means of the formula:

The sulfur dioxide content is calculated as follows:

$$SO_2 = \frac{(A)\quad(25)}{S} \times \frac{(64)}{(34)} \times (1000)$$

A, the H_2S concentration per ml. of zinc acetate solut'on as obtained from the standard curve of Optical Density at 745 mμ vs. concentration of hydrogen sulfide in μ-g. per ml. (p.p.m.).

S, ml. of standard coffee brew added to the first stannous chloride solution.

Measurement of mercaptans in coffee brew (as sulfhydryls)

Reagents: Cadmium acetate, dissolve 10 g. of cadmium acetate in sufficient redistilled H_2O to make 100 ml.

Buffer, dissolve 69 g. of sodium dihydrogen phosphate monohydrate in 750 ml. of redistilled H_2O. Adjust to pH 7 with 20% NaOH solution and dilute to one liter with redistilled H_2O.

Colloidal Sulfur, mix 1.6 g. of sublimed sulfur in 40 ml. of Carbowax 200 (Carbide and Carbon Chemicals Corp., New York, New York) and heat to 110° C. It is important not to exceed this temperature or else the stability of the suspension is diminished considerably. Decant the Carbowax (polyethylene glycol) solution of sulfur from the excess sulfur into 60 ml. of redistilled H_2O, stirring gently during the addition. This colloidal suspension is stable for a short time. It is best to use it within one or two hours of its preparation.

Zinc acetate, dissolve 20 g. of zinc acetate, C.P., in sufficient redistilled H_2O to make one liter. Add 5 drops of glacial acetic acid to prevent hydrolysis.

N-N-dimethyl-p-phenylenediamine sulfate, also called p-aminodimethylaniline sulfate, dissolve 1.000 g. of Eastman N-N-dimethyl-p-phenylenediamine sulfate in sufficient 2 plus 1 sulfuric acid (two parts concentrated H_2SO_4 plus one part redistilled H_2O, cooled to room temperature) to make one liter. Can be kept for two months under refrigeration.

Ferric chloride, dissolve 2.7 g. of ferric chloride hexahydrate in 50 ml. of concentrated HCl and dilute to 100 ml. with redistilled H_2O.

Procedure

1. Add 350 ml. of the standard coffee brew, 50 ml. of buffer solution, and 2 ml. of cadmium acetate solution, in this order, to a round bottom one-liter distilling flask.
2. Connect to an all-glass still and distill over 100 ml. of distillate into the bottom half of an ice jacketed, 250 ml., Drechsel-type gas washing bottle.
3. Disconnect from the still and place the top half of the Drechsel-type gas washing bottle on the lower half.
4. Connect the inlet portion of the bottle to a tank of prepurified nitrogen, and the exit portion to the open end of a glass bubbling tube. All tubing is tygon.
5. Immerse the "holed" end of the glass bubbler in 20 ml. of zinc acetate solution in a graduate cylinder.
6. Add 5 ml. of buffer solution and 10 ml. of colloidal sulfur suspension to the distillate, and start the nitrogen bubbling through, at a moderate rate for one hour.
7. After one hour, the nitrogen is stopped and the graduate cylinder detached from the nitrogen train.
8. The glass bubbler is left in the graduate cylinder for the remainder of the procedure. The cylinder is then placed in an ice bath (10° C., or less).
9. Add 2.5 ml. of N-N-dimethyl-p-phenylenediamine sulfate solution followed by 0.5 ml. of ferric chloride solution, and make up to 25 ml. with 2% zinc acetate solution.
10. Mix gently and allow to stand one hour at room temperature.
11. The optical density of the solution is then obtained by placing an aliquot in a 1.0 cm. Corex glass cell and reading at 745 mμ on a Beckman Model D.U. Spectrophotometer.

The amount of H_2S obtained from the sample, under this treatment, is determined by reading off of the same standard curve as was used for the H_2S determination. The quantity of Mercaptans, calculated as SH, is derived from the H_2S by means of the formula:

$$SH = \frac{(A)\quad(25)}{S} \times \frac{(33)}{(34)} \times (2) \times (1000)$$

A, the H_2S concentration per ml. of zinc acetate so'ution as obtained from the standard curve of optical density at 745 mμ vs. concentration of hydrogen sulfide in μg. per ml. (p.p.m.)

S, ml. of coffee brew to be distilled.

RESULTS

The recovery of hydrogen sulfide from water solutions of known concentration and the recovery of hydrogen sulfide, added to Standard Coffee Brew in known quantities, were determined (Table 2). Recovery from water solution was nearly 90% while with Standard Coffee Brew it varied with the quantity of hydrogen sulfide added. Freshly prepared standard coffee brew yielded no hydrogen sulfide. Holding standard coffee brew at standard experimental conditions yielded no hydrogen sulfide, even after 24 hours (Table 3).

The recovery of sulfur dioxide from water solutions of known concentrations was approximately 94% while the recovery of added sulfur dioxide from freshly prepared stan'ard coffee brew was approximately 100% (Table 2). The sulfur dioxide content of prepared standard coffee brew, was 27 parts per billion (Table 4).

The mercaptans content, determined as sulfhydryl (−SH), of freshly prepared standard coffee brew, was determined to be 56.7 parts per billion (Table 5).

DISCUSSION

The results of hydrogen sulfide determinations indicated no hydrogen sulfide in any of the coffee beverages tested (Table 3). This was the case even though the method used was sensitive to as little as one part of hydrogen sulfide per ten million parts of solution.

There is the possibility that the hydrogen sulfide was driven off at the brewing temperature. Even holding samples of standard coffee brew at various temperatures, for various lengths of time, failed to

TABLE 1

Organoleptic analysis of standard coffee brew
Mean Hedonic Rating at $t_{.05}$

Time of holding	Holding temperature (° C.)			
	63	73	83	93
(hours)				
0	7.36 ± .16	7.36 ± .16	7.36 ± .16	7.36 ± .16
1	6.17 ± .35	6.12 ± .40	6.34 ± .40	6.84 ± .26
3	6.23 ± .28	5.72 ± .52	6.00 ± .52	4.89 ± .36
6	4.77 ± .37	5.00 ± .47	3.84 ± .36	3.98 ± .39
24	2.78 ± .29	2.39 ± .33	2.72 ± .39	2.00 ± .23

From Segall, S., and B. E. Proctor, The influence of high temperature holding upon the components of coffee brew, *Food Technol.*, **13**, (5), (1959).

TABLE 2

Recovery studies on SO_2 and H_2S Added to redistilled water and standard coffee brew

Recovery system studied	Quantity added	Quantity recovered	Quantity recoverable	Recovery
	(μg./100 ml.)	(μg./100 ml.)	(μg./100 ml.)	%
H_2S in Redistilled Water	3.0	2.8	.....	93.5
	12.8	11.0	.....	86.0
	16.2	14.8	.....	91.4
	22.5	20.0	.....	89.0
H_2S in Standard Coffee Brew	22.5	18.1	20.2	90.0
	20.0	24.8	26.0	95.4
	48.4	34.0	43.3	79.0
SO_2 in Redistilled Water	46.5	40.5	.....	87.0
	41.0	37.3	.....	91.2
	41.0	39.1	.....	95.5
	41.0	41.4	.....	101.0
SO_2 in Standard Coffee Brew	46.5	41.0	43.6	94.2
	41.0	40.4	38.5	105.0
	41.0	41.7	38.5	108.2
	41.0	39.6	38.5	102.9

[1] Based on the Mean % recovered from redistilled water. (89.9% for H_2S and 93.8% for SO_2).

TABLE 3

H_2S content of standard coffee brew

Time of holding	Temperature of holding	Sample size ml. std. brew	H_2S content
(hours)	(° C.)		(p.p.m.)
0	....	30.0	0
0	....	30.0	0
0	....	200.0	0
0	....	200.0	0
3	63	100.0	0
3	73	100.0	0
3	83	100.0	0
3	93	100.0	0
24	63	100.0	0
24	73	100.0	0
24	83	100.0	0
24	93	100.0	0

produce any trace of hydrogen sulfide (Tables 2 and 3). These findings are not in agreement with those of Hughes and Smith (*9*) who reported that coffee had a hydrogen sulfide content of approximately 3.5 μ-g. per g., and that the "concentrations of hydrogen sulfide in coffee decoctions as normally prepared for drinking would be about one-tenth of the above values" (approximately 0.3 μ-g. per g. or about 3 parts per 10 million).

Hughes and Smith (*9*) maintain that "hydrogen sulfide may be involved in the changes which take place when coffee (brew) is over-heated or kept hot for a long time, and may partially explain the variation in flavor obtained by different methods of preparation." The results of studies reported here, on coffee brew which had been held at high temperatures for long periods of time, indicated that hydrogen sulfide formation was either not taking place at all, or in such small quantity as to be negligible in its effect on the flavor.

The sulfur dioxide content of coffee brew was found to be quite small (27 parts per billion, Table 4). At the higher holding temperatures, the sulfur dioxide content shows a marked tendency to decrease with increased length of holding time. The sulfur dioxide content is apparently unchanged over the 24-hour holding period, when the holding temperature is as low as 63° C. At 73° C. and higher, there is a decreasing trend in the sulfur dioxide content after only three hours of holding. The vanishing point is approached after 24 hours.

It is apparent that the method of analysis gave somewhat irregular results. Apparently the concen-

TABLE 4

The sulfur dioxide content of standard coffee brew

Time of holding	Sulfur dioxide concentration in parts per billion							
	Holding temperature							
	63° C.		73° C.		83° C.		93° C.	
	p.p.b.	p.p.b. at "0"	p.p.b.	p.p.b. at "0"	p.p.b.	p.p.b. at "0"	p.p.b.	p.p.b. at "0"
(hours)		%		%		%		%
0	27	.....	27	.....	27	.....	27	.....
1	23	85.2	23	85.2	23	85.2	28	103.8
3	4	14.8	14	52.0	4	14.8	13	48.2
6	23	85.2	4	14.8	4	14.8	23	85.2
24	22	81.2	4	14.8	0	0	0	0

TABLE 5

The mercaptans content (expressed as sulfhydryls) of standard coffee brew

Time of holding	Mercaptan concentration (as —SH) in parts per billion							
	Holding temperature							
	63° C.		73° C.		83° C.		93° C.	
	p.p.b.	p.p.b. at "0"	p.p.b.	p.p.b. at "0"	p.p.b.	p.p.b. at "0"	p.p.b.	p.p.b. at "0"
(hours)		%		%		%		%
0	56.7	.....	56.7	.....	56.7	.....	56.7	.....
1	49.5	87.3	57.9	102.0	71.0	125	71.0	125
3	50.5	89.1	47.2	83.5	51.9	91.6	54.1	95.5
6	52.2	92.2	53.1	93.8	45.9	81.0	39.5	69.6
24	37.0	67.0	31.2	55.0	28.0	49.4	24.1	42.5

tration of sulfur dioxide in the coffee brew was at the lower end of the sensitivity scale for this method. Even so, the results were enough to give a reasonable picture of sulfur dioxide behavior in coffee brew (Tables 2 and 4).

The concentration of sufur dioxide found is well below taste threshold. .According to Brenner, Owades and Fazio (*6*), the threshold of sulfur dioxide in deionized water is 50 p.p.m. Even sensitive tasters could detect sulfur dioxide only when the concentration was at least 10 to 20 p.p.m.

It is possible for sulfur dioxide to have some indirect taste effect, even in the low concentrations in which it has been found here in coffee brew. This would be the case if the action were one of chemical combination with some of the other flavor compounds. Sulfur dioxide has a marked chemical activity with carbonyl compounds, or double bonds, etc. (*13*). The influence that sulfur dioxide has on coffee is highly problematic.

The results of the mercaptans determination indicated that this class of compounds did play an important role in the flavor of coffee brew (Table 5). The mercaptans content of coffee brew, determined as total sulfhydryls, was 56.7 parts per billion. The mercaptans content was observed to increase initially when the coffee brew was subjected to the higher holding temperatures for various lengths of time. The mercaptans increase followed the same general pattern as that of the organoleptic tests.

Inspection indicates the similarity of these data to the organoleptic data. Except for the 63° C. samples, after one hour the mercaptans content for all holding temperatures fell off as the holding time increased. The behavior of this part of the mercaptans content followed the general pattern of the organoleptic analyses (Tables 1 and 4).

It is interesting to note that mercaptans formation seems to be taking place at the high holding temperatures. It is almost as if a miniature roasting procedure were being carried out. When the coffee brew is held too long, there is apparently more breakdown than formation of this class of flavor compounds.

From the results of the organoleptic determinations, and from the stability characteristics exhibited by this group of compounds, it is reasonable to assume that mercaptans could play a significant role in coffee flavor. These data present a quantitative picture of the interrelationship of coffee flavor and mercaptans.

The possibility of the mercaptans content of coffee brew serving as a supplementary means for the objective evaluation of coffee is noted. This might present an important adjunct to present cup testing methods used for coffee flavor testing.

SUMMARY AND CONCLUSIONS

The hydrogen sulfide content of brewed coffee was determined by the use of a modification of the technique of Brenner, Owades, and Golyzniak (*2*). For the particular blend of coffee used in these studies no hydrogen sulfide was found in coffee brew.

Sulfur dioxide was detected and quantitatively measured in coffee brew by a modification of the method of Brenner, Owades, and Fazio *(6)*. The quantities found were below the organoleptic threshold levels reported for this compound. It was found that the content of sulfur dioxide in the coffee brew generally tended to decrease with increasing length and temperature holding.

The sulfhydryl (mercaptans) content of coffee brew was determined by a modification of the technique of Brenner, Owades, and Fazio (*5*), and of Brenner, Owades, Gutcho, and Golyzniak *(3)*. There seemed to be a relationship between the mercaptans content of a coffee brew and the organoleptic rating of these brews. This suggests that the mercaptans content of coffee brew is closely associated with flavor and flavor changes.

Acknowledgment

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On the Color of Coffee. III.

Effect of Roasting Conditions on Flavor Development for a Given Color. Role of Initial Moisture Level on Roasting Characteristics of Green Coffee Beans*

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THE COLOR of the roasted coffee bean determined subjectively or by physical objective measurements is the criterion by which a roast is evaluated by the roaster operator. It is indisputable that flavor development parallels color development, for, as we compare light with medium, with high, with French roasts, we note marked changes in the flavor characteristics of the brewed coffee. Under normal industrial practice, small batches of the various kinds of green beans to be included in the commercial blend are roasted in laboratory-size roasters. Subjective evaluation of the color determines when the roast is considered "finished." Time and temperature are not controlled. Thus, color development is used as the indication of flavor development, and the possibility of even minor variations in time and temperature affecting flavor development is ignored. An expert coffee taster then defines the composition of the blend by tasting the brews of the individual samples roasted in this manner.

The major objective of the present report was to determine the existence of time-temperature equivalents for roasts of a given color. This was performed with a modified Jabez-Burns roaster described below. Brews of the resulting roasts were then evaluated for flavor differences by a trained taste panel. The effect of varying time and temperature to attain a given color on the ultraviolet-absorbing components was also investigated.

Preliminary work on the role of moisture content in beans of a given variety on the roasting characteristics of the bean is also discussed.

EXPERIMENTAL

Modified Jabez-Burns roaster. The coffee roaster used in previous experiments *(2)* has been modified further. The 2 burners in the fire box are coupled individually to the gas supply so that each may be controlled independently of the other. One of the burners is equipped with a General Controls type B650 valve which is controlled by the movement of the pen of the recording instrument. This burner can thus be controlled directly from the temperature-measuring thermocouple. The gas supply to the other burner is controlled by a proportioning Robertshaw-Fulton valve whose temperature-sensing bulb is inserted directly into the rotating chamber of the roaster. The temperature-sensing bulb for the proportionate controller and the temperature-sensing thermocouple are separated within the rotating chamber by less than ¼ inch. Pictorial representations of the modified roaster are shown in Figures 1 and 2.

In contrast to the previous arrangements, the heat supply is controlled by changes in temperature within the roaster proper rather than by changes in temperature of the input air to the roaster. This results in a much faster come-up time to the control temperature. In the previous arrangement the air temperature to the bean was maintained at a fixed temperature, and the temperature above the beans within the roaster itself then rose as the beans came into equilibrium with a constant input temperature. At no time during the roast did the beans actually attain the control temperature of the input air. In the present case, when the beans are first placed into the roaster the temperature of the input air rises far above the control point and the heat input is substantially increased in order to raise more quickly the temperature of the beans to the control point. As the temperature of the beans reaches the control point, the input air temperature is automatically reduced so that the roaster is maintained at a constant temperature during the rest of the roast. A typical time-temperature curve is shown in Figure 3. This method of control partially alleviates the difference in come-up time when the roast temperature is changed. The time now required to bring the beans within 30° F. of the control temperature is less than 3 minutes, whereas previously it was of the order of 15 minutes.

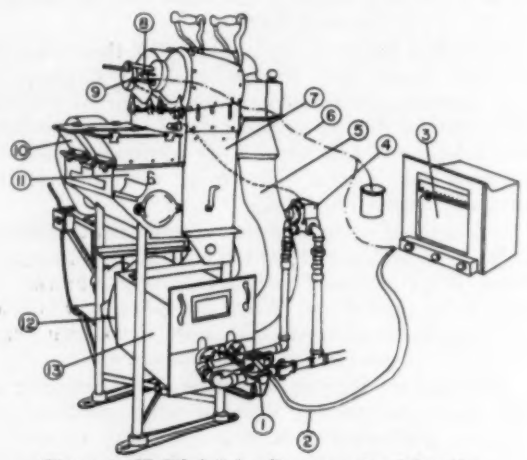

Figure 1. Modified Jabez-Burns roaster (view 1).

(1) General controls B-50 pilot powered solenoid valve. (2) Control lines from solenoid to cam operated microswitch in recorder. (3) Variable span, variable zero suppression Brown Recorder. (4) Robertshaw-Fulton proportional gas valve. (5) Return air duct. (6) Thermocouple leads. (7) Plenum chamber (hot air). (8) Thermocouple leads. (9) Temperature sensing bulb for proportional control. (10) Cooling trays. (11). Plenum chamber (cooling air). (12) Blower scroll. (13) Fire box, with two burners independently controlled.

* Presented at the 19th Annual Meeting of the Institute of Food Technologists, Philadelphia, May 17, 1959.

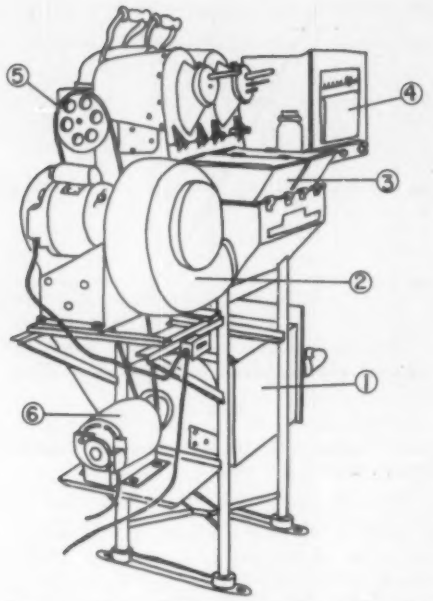

Figure 2. Modified Jabez-Burns roaster (view 2).
(1) Fire box. (2) Cooling blower. (3) Cooling trays. (4) Recorder. (5) Drive for rotating roasting chambers. (6) Heating fan motor.

The time required for the beans to cool after roasting may be a factor in the flavor or color evaluation. The roaster in this set of experiments was therefore equipped with a ½-h.p. centrifugal blower which pushed a stream of cold air through the cooling pans on the front of the roaster. The pans were equipped with screening so that the beans would not be blown out of the trays while cooling took place. When the roast was completed, the beans were dumped into the cooling pan, the screen fastened to its top and blower turned on. The time required for cooling of the beans to approximately room temperature was of the order of 1½ to 2 minutes using this system. The use of a forced draft cooling cycle materially aided in securing reproducibility of the roasting procedure.

Coffee samples. The following green beans were obtained from the Folger Coffee Company:

(1) Colombian: Prime-quality green beans of uniform size were chosen as the raw material for flavor evaluation. The sack was stored in a plastic container to prevent absorption of foreign odors and loss of moisture.

(2) Santos; and (3) Robusta: These 2 varieties were used in studies on the role of initial moisture content on roasting characteristics.

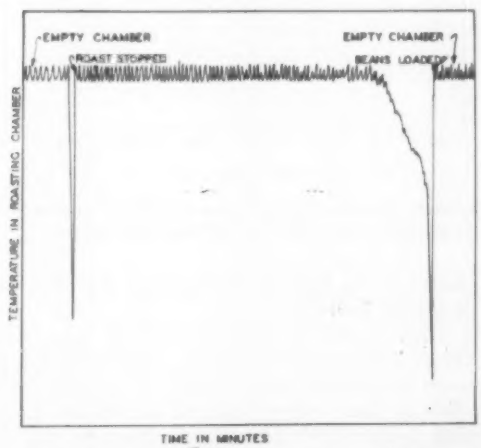

Figure 3. Time-temperature chart of a typical roast.

Grinding of samples. The roasted samples were passed three times through a commercial grinder (Hobart Manufacturing Company) set to fine grind as previously described *(2)*.

Color measurements. Reflectance measurements were made on a Colormaster Differential Colorimeter (Manufacturers Engineering and Equipment Corporation) as previously described *(1)* with the exception that a lucite rather than a glass cell was used.

Preparation of aqueous extracts. Five gram aliquots of the finely ground samples were extracted for 3 minutes with 50 ml. of H_2O heated to 212° F., then rapidly filtered through glass wool followed by filtration through Whatman No. 42 filter paper.

Measurement of ultraviolet-absorbing components. The ultraviolet absorption spectra were determined in duplicate on the above extracts diluted 1 to 250 for the range 270–340 mμ on a Beckman DU Spectrophotometer.

Determination of time-temperature equivalents. It was arbitrarily decided to define 5 conditions of time and temperature which would yield a roast with a tristimulus Y value of 4.0%. Roasting temperatures of 365–425° F. at 15° F. intervals were chosen and the time required for each roast was determined experimentally. The conditions for defining 2 pairs of time-temperature equivalents to yield roasts of Y = 5.0% and Y = 6.0%, respectively, at roasting temperatures of 365° and 380° F. were similarly established. Areas under the time-temperature curves were measured with a planimeter. Thus, ten combinations for Y = 4.0% and one each for Y = 5.0% and Y = 6.0% were secured for taste testing.

Organoleptic tests[b]

(1) Selection of Coffee Panel: A panel of 12 judges was selected from a group of twenty persons for their ability to distinguish between small differences in concentration of brewed coffee. The triangle test methodology was used, and the significance levels were taken from the table prepared by Roessler *et al. (3)*.

(2) Preparation of Brew: A brew was prepared by adding the freshly-ground "drip" grind coffee, 5 g. per 100 cc., to water at 195° F. in a stainless steel container. The mixture was stirred for one minute and then passed through a 32-mesh, stainless steel wire cloth. The brew was held at 150° F. in a water bath. The coffee was served at 115–120° F. in coded demi-tasse cups, glazed black inside.

(3) Design: Triangle test design was also used for the evaluation of experimental samples. All possible combinations of the samples were presented. Two (in two cases, three) replications of each combination were tested. The coffee was tasted the day following roasting, and care was taken to hold a tasting session daily to prevent "staling" of the judges. At each session all possible permutations of two different combinations were presented at random to the panel (i.e. if conditions A and B were being tested, then AAB, ABA, BAA, ABB, BAB, BBA, were presented). These evaluations were done in individual taste booths under low red illumination.

Variation in moisture content of green beans. The moisture content of Santos and Robusta green beans was determined by the vacuum oven method as follows: 30 g. aliquots of coarsely ground beans (one passage through the Hobart grinder set to coarse) were dried in a vacuum oven at *ca* 190° F. and *ca* 20 in. mercury for 24 hours. Per cent moisture was calculated on the basis of weight loss under these conditions. To hydrate or partially dehydrate samples of the two varieties, 500 g. aliquots were placed in desiccators and held at different levels of relative humidity as follows:

[b] This section was organized and supervised by Anesiades Leonard. The serving temperature and procedure for taste-testing is based on unpublished work by Marion Simone, Anesiades Leonard and Sherman Leonard, to whom our thanks are due.

(1) over water—*ca* 100% R.H. at room temperature
(2) over saturated calcium chloride—*ca* 30% R.H. at room temperature
(3) over saturated zinc chloride—*ca* 10% R.H. at room temperature

Increase or decrease in weight for 10 g. aliquots of each sample held at the 3 conditions of relative humidity was recorded at intervals for 3 weeks. Final moisture level was calculated on the basis of gain or loss in weight of the samples of known initial moisture content. The samples were stored in tightly stoppered brown glass bottles at 32° F. until roasted. Moisture levels were checked at the time of roasting by the vacuum oven method. A 200 g. aliquot of each sample was roasted at 395° F. for 15 minutes. The samples were weighed upon completion of the roast.

RESULTS AND DISCUSSION

Time-temperature equivalents. The modifications effected on the Jabez-Burns laboratory roaster made possible precise repetition of a roast to a given color once the conditions were established. The 2 burners operating independently with one set to cut in and out at a predetermined temperature resulted in a come-up time of 1.25 to 2.5 minutes, depending on the final temperature desired, the lower the temperature the shorter the come-up time.

In Table 1 the experimentally determined time-temperature equivalents and the areas under the curves for Y = 4.0, 5.0, and 6.0% for the Colombian beans are summarized.

From the data in Table 1, Figure 4 was constructed for the conditions resulting in a tristimulus Y value of 4.0%. Here we have plotted area under the curve against the temperature of the roast; this is essentially a linear function between 380° and 425° F. For each 15° increase in roasting temperature in this range there is approximately a 3 sq. in. decrease in area under the curve. Between 365° and 380° F., the slope of the curve is radically different. Here we have a decrease of 11 sq. in. area for the 15° increase in temperature and the rate of color development is markedly retarded.

On further examination of Table 1, we note that the increase in area under the time-temperature curve in going from a Y value of 6.0% to a Y value of 5.0% is essentially the same for the 365° and the 380° F. roasts, in the former case, the change is 3.2

TABLE 1

Time-temperature equivalents (Colombian coffee)

Condition	Y	Time	Temp.	Area under curve[1]
		(min.)	*(° F.)*	*(sq. in.)*
A	4.0	26	365	46.3
B	4.0	18	380	35.2
C	4.0	15	395	32.0
D	4.0	12.5	410	29.0
E	4.0	10	425	24.8
F	5.0	18	365	31.0
G	5.0	14	380	28.0
H	6.0	15	365	27.8
J	6.0	12.5	380	24.5

[1] On a 10" Honeywell-Brown recorder with no suppression, the zero line would represent the cold junction temperature, namely 32° F. In these experiments, the zero was suppressed so that the zero-line on the chart represented 260° F., and the amplification was adjusted so that the 100 line on the chart represented 560°. Since this is an arbitrary choice, units are reported as area rather than in degree-minutes.

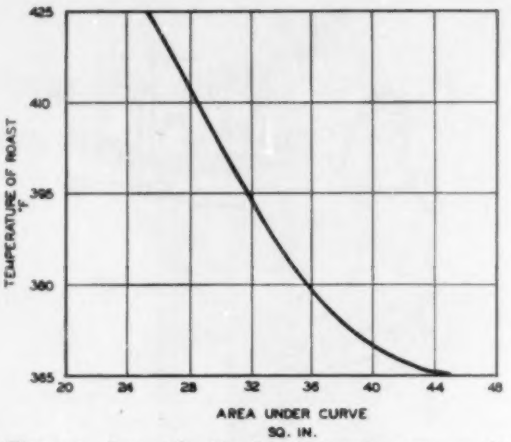

Figure 4. Area under the time-temperature curve vs. temperature of roast for Y = 4.0%.

sq. in. and in the latter 3.5 sq. in. However, as the roasting time is extended to attain a roast with a Y value of 4.0%, the parallelism no longer pertains. Although in both cases color development proceeds at a more rapid rate between Y = 6.0% and Y = 5.0% than between Y = 5.0% and Y = 4.0%, the latter change is significantly slower at 365° F. than at 380° F., as shown graphically in Figure 5.

The optical density measurements for the ultraviolet absorbing components at 285 and 320 mμ for

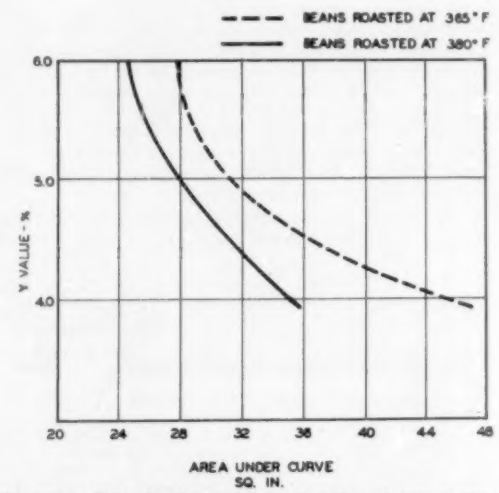

Figure 5. Color development as a function of area under the time-temperature curve for two roasting temperatures.

the 5 time-temperature equivalents for Y = 4.0% are listed in Table 2.

We have previously characterized the main bands at 320 and 285 mμ in aqueous coffee extracts, and discussed variations in the ratio of the two optical densities at these wave lengths as affected by the roasting temperature *(1)*. Table 2 shows that this ratio is reproducible for a single variety roasted at

TABLE 2

U.V. Absorbing components for five time-temperature equivalents for Y = 4.0% (Colombian Coffee)

Condition	Temp.	D(285)	D(320)	D(285)/D(320)
	(° F.)			
A	365	1.02	.940	1.08
B	380	1.01	.950	1.06
C	395	.780	.720	1.08
D	410	.870	.800	1.09
E	425	.800	.740	1.08

5 different time-temperature equivalents to a given Y, in this instance 4%, with a ratio *ca* 1.08. Errors in absolute values had been evaluated at ±16% *(1)*, which must be ascribed almost entirely to efficiency of extraction. We conclude that the level of ultraviolet absorbing components is essentially the same for conditions A and B, and lower for conditions C, D and E. This suggests that the ultraviolet-absorbing components are destroyed somewhat more slowly when coffee is roasted to a given color at lower temperatures.

Organoleptic evaluation of flavor differences. Results of the triangle taste tests for all the possible permutations for the 5 sets of conditions resulting in a roast with a tristimulus Y value of 4.0%, and for the 2 sets of conditions each for Y values of 5.0 and 6.0% are tabulated in Table 3. When condition A (365° F.) was compared with the roasts at higher temperatures (B-380° F., C-395° F., D-410° F., and E-425° F.), it was found that the ability of the panel to differentiate correctly was related to the difference in roasting temperatures, illustrated in Figure 6. B however was differentiated equally from either C, D or E, without regard to the temperature difference. It is not possible to explain why the panel could discriminate at the 1% level of significance between D and E, and not between C and D or C and E. That the panel was unable to distinguish differences in flavor between the 365° and 380° F. roasts was further substantiated when samples were presented roasted to Y values of 5.0 and 6.0%, respectively, at these temperatures. It is apparent from these results that color *per se* cannot be used as the only indication of flavor development. Except for the brews from beans roasted at the lower temperatures, significant differences in flavor were noted for two-thirds of the combinations tested. Thus, it must be concluded that while flavor development parallels color development, reactions leading to the qualitative and quantitative formation of flavor-producing components will be affected by the conditions of the roast. Differences in flavor are not reflected in differences in ultra-violet-absorbing components under varying conditions of time and temperature.

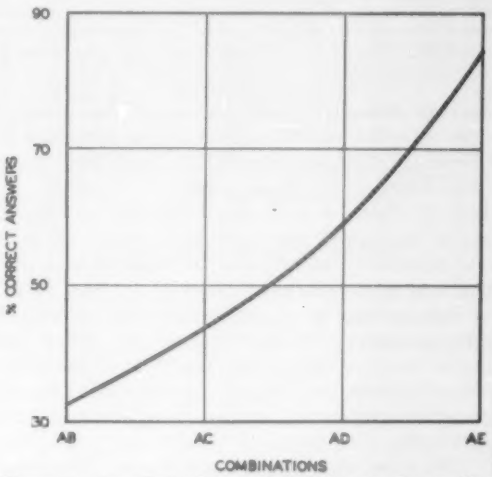

Figure 6. An effect of a marked difference in roasting to constant color on the ability to evaluate flavor differences. (Note: this trend disappears, as comparisons are made more nearly simulating commercial roasts.)

Role of initial moisture content on roasting characteristics of Santos and Robusta beans. Samples of Santos and Robusta green beans kept at room temperature under normal atmospheric conditions for 5 months lost approximately 20% of their initial moisture content, i.e. the moisture level was reduced from *ca* 10% to *ca* 8% under these conditions. The hydrated and partially dehydrated samples had remained virtually unchanged at 32° F. The moisture

TABLE 3

Organoleptic evaluation of flavor differences[1]

	Combinations											
	AB		AC		AD		AE		BC		BD	
Replication	N.T.	C.A.	N.T.	C.A.	N.T.	C.A.	N.T.	C.A.	N.T.	C.A.	N.T.	C.A.
1	12	4	12	4	11	8	11	10	11	7	11	2
2	10	3	10	5	10	4	10	7	12	8	12	8
3									11	5	11	9
Total	22	7(ns)	22	9(ns)	21	12(a)	21	17(c)	34	20(b)	34	19(b)
% Correct answers	31.8		40.9		57.1		80.9		58.8		55.8	

	Combinations											
	BE		CD		CE		DE		FG		HJ	
Replication	N.T.	C.A.	N.T.	C.A.	N.T.	C.A.	N.T.	C.A.	N.T.	C.A.	N.T.	C.A.
1	10	6	10	4	10	3	10	5	11	4	11	2
2	12	8	12	7	12	4	12	9	12	4	12	3
3												
Total	22	14(b)	22	11(ns)	22	7(ns)	22	14(b)	23	8(ns)	23	5(ns)
% Correct answers	63.6		50.0		31.8		63.6		34.7		21.7	

[1] Combinations AB to DE are for a Y value of 4.0%; FG, of 5.0%; HJ, of 6.0%.

N.T. and C.A. refer to the number of tasters, and correct answers, respectively; ns, not significant at the 5% level; and a, b, c, significant at the 5%, 1% and 0.1% levels respectively.

TABLE 4

Roasting characteristics of Santos and Robusta beans at various levels of moisture content

Sample	Moisture content (to nearest 0.5%)	Loss in weight on roasting	Y value	D(285)	D(320)	D(285)/D(320)
	(%)	(%)	(%)			
Santos at normal atmospheric conditions	8.0	12.0	4.6	.740	.815	.91
Santos equilibrated over H_2O	19.0	19.0	5.5	.790	.780	1.01
Santos equilibrated over sat. $CaCl_2$	7.5	11.0	4.6	.690	.718	.96
Santos equilibrated over sat. $ZnCl_2$	5.5	8.0	4.5	.670	.690	.97
Robusta at normal atmospheric conditions	8.0	12.0	9.0	1.190	1.280	.93
Robusta equilibrated over H_2O	15.0	15.5	10.4	1.265	1.330	.95
Robusta equilibrated over sat. $CaCl_2$	7.5	11.0	9.2	1.155	1.210	.95
Robusta equilibrated over sat. $ZnCl_2$	6.0	9.0	9.1	1.235	1.285	.96

content at time of roast, per cent loss in weight on roasting, the resulting tristimulus Y values and the level of ultraviolet-absorbing components in the aqueous extracts are summarized in Table 4.

Data in Table 4 show that for the partially dehydrated beans and the beans held at normal atmospheric conditions, weight loss on roasting is a linear function of initial moisture content. In each of these cases only about ⅔ of the weight loss on roasting can be accounted for as water in the green bean. Thus, it must be concluded that loss of weight on roasting involves not only a loss of water, but also of volatile components and of breakdown products by pyrolysis.

In the case of the hydrated beans, the loss in weight on roasting is proportionately less severe. Beans with a moisture content of 20% should have lost about 30% of their weight on roasting to an acceptable color. This means that conditions for roasting beans with high initial moisture contents would be quite different from those for beans with lower moisture contents. This requires further study.

Differences in initial moisture level were found to have no significant effect on the level of ultraviolet-absorbing components in the aqueous extracts of the various roasts for either the Santos or the Robusta beans.

SUMMARY

The modified Jabez-Burns Laboratory Roaster was used to determine time-temperature equivalents at five roasting temperatures to give a roast with a tristimulus Y value of 4.0% and at two roasting temperatures for Y values of 5.0 and 6.0%. A linear relation was found between the temperature of the roast and the area under the time-temperature curve for roasting temperatures between 380° and 425° F. Color development is retarded at 365° F.

Samples of coffee roasted to tristimulus Y values of 4.0, 5.0, and 6.0% were brewed under controlled conditions, and the twelve resulting combinations were presented at random to a trained panel for evaluation of flavor differences. Triangle test methodology was used. At the 5.0 and 6.0% Y value levels differences in roasting conditions were not reflected in differences in flavor. At the 4.0% Y value level, significant differences were found when the 365° F. roast was compared with the 395, 410, and 425° F. roasts. Variations in the ability to discriminate are considered and it is shown that roasting to a given color does not suffice. The roasting conditions must be controlled to insure the development of the desired flavor characteristics.

An experiment designed to study the role of moisture content in the green bean on its roasting characteristics is described. Color development is unaffected when beans of a given variety at lower moisture levels are roasted under identical conditions. Significant differences in weight loss and color development were found for the hydrated samples, and high initial moisture content significantly affects the roasting characteristics of beans.

Acknowledgment

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Tenderness at Various Muscle Depths Associated with Poultry Processing Techniques*

(Manuscript received May 11, 1959)

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SEVERAL WORKERS *(2, 4, 5, 6, 7)* have demonstrated that chicken breast meat is toughened by excessive scalding. Similar observations have been reported for turkeys *(3)*. The depth to which this toughening action penetrates has not been reported. In view of the desirability of improving the tenderness of poultry meat, it was decided to investigate the penetration aspects of the scald problem. This paper describes the tenderness pattern at different depths from the surface obtained by varying scald process techniques and also describes an objective method for measuring meat tenderness with relatively small samples.

METHODS

In this study twenty-seven 16 week-old Leghorn pullets obtained from the Purdue University poultry farm were used. They were slaughtered and eviscerated one at a time so that variance due to uncontrollable factors might be held to a minimum.

The birds after being in an inverted position for 1 minute were slaughtered by cutting the arteries under the left mandible. Free bleeding was allowed for 90 seconds. Scalding was accomplished in a small thermostatically-controlled batch-type scalder, but water temperature was checked with a thermometer for each bird.

Scald time was 20, 40 or 80 seconds at temperatures of 130° F., 140° F. or 150° F. for individual birds.

The birds were picked utilizing the soft (hollow) fingers of a semi-automatic drum type picker, with 40 seconds allowed for each bird. This tended to reduce the toughening effect of the picker to a relatively low and constant level.

Following evisceration by the roaster method, birds were held in an ice and water solution for 24 hours to permit normal aging. They were then wrapped in 2 layers of aluminum foil, placed in a reel-type oven at 325° F. and cooked for 2 hours. After cooking, birds were cooled to 34° F. by holding them on racks in a walk-in mechanical cooler for a minimum of 12 hours.

After cooling, the entire pectoralis major and the pectoralis minor muscles were removed in one piece from each side with a knife. The minor muscle was left attached to the major to facilitate holding the major in a rigid condition during the slicing process. The piece of meat was then placed in a commercial meat slicer with the exterior side pressed firmly against the slicer fence. Passing the power driven blade through the positioned piece, it was possible to obtain slices of the *pectoralis major* muscle that were 2 mm. thick. This procedure enabled one to obtain 3 successive slices before the blade became sufficiently soiled that it began to tear the slices. The blade had to be cleaned after each muscle.

Each of the 3 slices of each muscle were uniformly cut into a rectangular shape of 2.5 x 6.5 cm. using a special cutting device developed by Dodge *(1)*. This sample size was used because it exactly fitted across the shearing surface of the sample box on the Kramer shear press used. Immediately after the samples were cut they were placed between two strips of aluminum foil to prevent dehydration and remained so covered, except for weighing, until placed in the shear press. Sample weights for the entire experiment averaged 5.2 g. Sample weights ranged from 4.2 to 6.0 g.

* Journal paper number 1423 of the Purdue Agricultural Experiment Station.

The shear press sample box was immersed in tap water prior to placing each meat sample in it. The purpose was two-fold: to cleanse the box, and to provide uniform moisture conditions for each determination.

Because of the small sample size, it was necessary to depart from the usual procedure in using the Kramer shear press. It was necessary to operate the hydraulic cylinder at 10 pounds per square inch of pressure instead of the usual 150 pounds. It was also necessary to make visual observations of maximum shear readings on the indicator dial of the force gauge used as the level of resistance to shear for some samples was too low to overcome the drag of the maximum needle.

RESULTS AND DISCUSSION

Table 1 summarizes the tenderness determinations obtained at different muscle depths with various scald temperatures and times. There was a decline in shear pressure as depth from the exterior surface increased (Figure 1). This was consistent within all treatments and was of greatest magnitude for the groups which received the more severe treatment, i.e., longer scald times at higher scald temperatures. In general, the exterior layers required over twice as much force to shear as did the innermost layers. Plotted points in Figure 1 represent the average shear force of all scald time and scald temperature variations for any given layer.

TABLE 1

Average shear press values by temperature and time of scald and by muscle depth layer[1]

Scald temp.	Scald time	Muscle depth layer		
		L_1 (0-2mm)	L_2 (2-4mm)	L_3 (4-6mm)
°F.	*seconds*	*lbs./gm.*	*lbs./gm.*	*lbs./gm.*
130	20	11.3	8.1	6.7
	40	12.9	9.6	7.7
	80	14.4	10.3	8.3
140	20	12.0	10.4	6.3
	40	12.4	10.4	8.4
	80	14.8	12.2	9.1
150	20	14.4	8.6	6.7
	40	15.7	11.0	8.1
	80	25.0	14.3	10.0

[1] Each average shear value given represents the average of duplicate determinations for shear values for 3 birds.

The least tender layer was the exterior layer of the group scalded at 150° F. for 80 seconds. The most tender layer of the experiment was the innermost layer of the group scalded at 140° F. for 20 seconds. Since the lower scald times and temperatures tended to result in more tender birds, the most tender layer would have been expected to be the innermost layer of the group scalded at 130° F. for 20 seconds. However, there may have been a slight toughening effect on this layer due to picker action. A scald of only

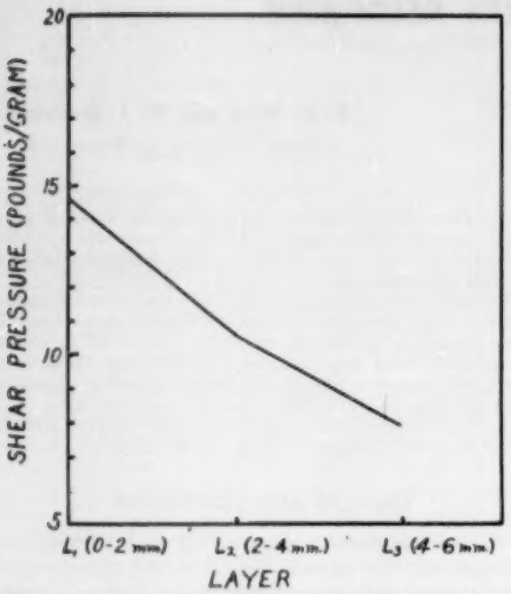

Figure 1. Effect of muscle depth layer on tenderometer shear pressure.

20 seconds at the relatively low temperature of 130° F. resulted in an underscalded bird and more force was required to pull feathers. Pool *et al. (6)* recently stated that part of the scald effect found by Shannon *et al. (7)* was probably picker effect.

The effect of scald temperature on tenderness by layer is illustrated in Figure 2. Plotted points represent the average shear force of all scald time variations for any given layer and scald temperature. There was relatively little increase in shear pressure (decrease in tenderness) at the innermost level, L_3, even at the 150° F. temperature. On the other hand, there was a sharp increase in shear pressure for the surface layer, L_1, especially at the 150° F. temperature. Average shear pressure for the middle layer, L_2, rose rather sharply from the 130° F. level to the 140° F. level, but it then remained relatively constant.

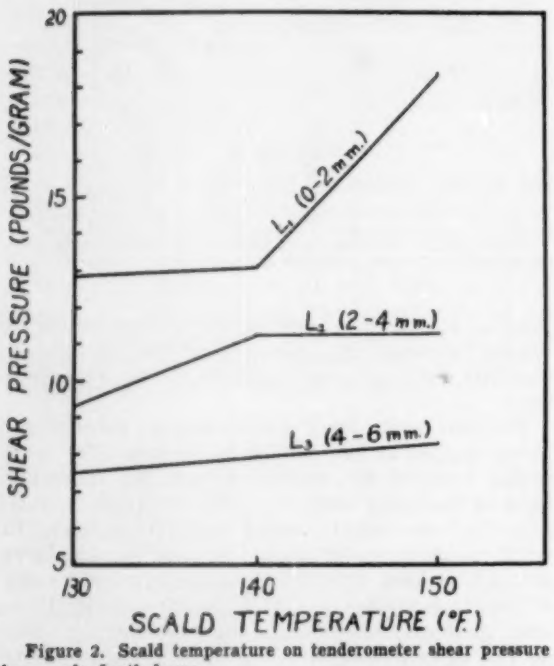

Figure 2. Scald temperature on tenderometer shear pressure by muscle depth layer.

The effect of scald time on tenderness by layer is illustrated by Figure 3. Plotted points represent the average shear force of all scald temperature variations for any given layer and scald time. All three layers were toughened by increasing the scald time, although, as with scald temperature, the innermost layer was affected least.

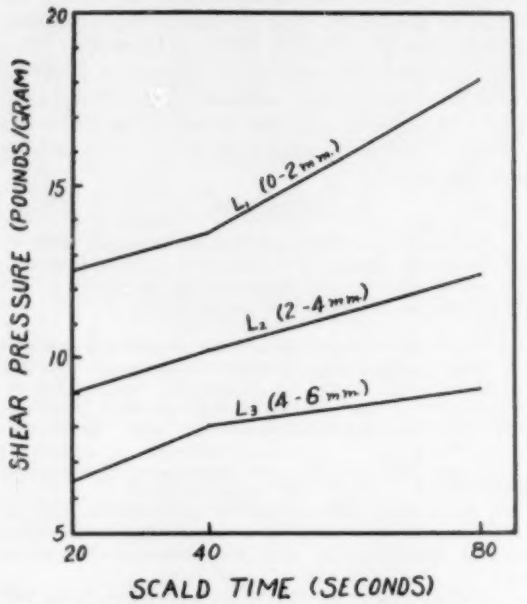

Figure 3. Effect of scald time on tenderometer shear pressure by muscle depth layer.

The study was subjected to an analysis of variance using a randomized block design. Variations due to temperature, time and layer were all highly significant while no combination of these variables produced a significant interaction.

The depth to which heat penetrates an object is a function of heat transfer rate multiplied by time. Since, in the ranges used, both scald temperature and scald time were found to be associated with tenderness of layered muscle tissue at a highly significant level, it would appear that the toughening effect of high temperature-long time scald is related to the depth at which the scald heat penetrates the muscle tissue. Thickness and density of skin as well as bird finish are, no doubt, also factors affecting heat transfer rate.

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SUMMARY AND CONCLUSIONS

The effects of various scald-time-temperature combinations on the tenderness characteristics of pectoralis major muscle at several distances from the surface were determined. Chickens were aged in an ice and water solution for 24 hours. They were then wrapped in aluminum foil and placed in an oven at 325° F. for 2 hours. All cooked birds were cooled to 34° F. prior to removal of the breast muscle. Three slices, each 2 mm. thick were cut from the exterior surface using a commercial meat slicer. From these slices 2.5 x 6.5 cm. samples were taken and subjected to a tenderness determination using a Kramer shear press.

Resistance to shear was related at a highly significant level to the depth at which samples were taken, to the temperature of scald water, and to the scald time duration. Under the conditions of this experiment, the toughening effect of high temperature-long time scald is related to the depth to which the scald heat penetrates the muscle tissue.

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Fouling of Evaporator Tubes by Tomato[a]

(Manuscript received June 22, 1959)

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Many canners could triple their production of tomato products if it were possible to eliminate the accumulation of burned tomato inside evaporator tubes *(1)*. In the concentration of tomato, a very low-solids fruit, all economies in evaporation are important. Fouling becomes intolerable when product quality begins to suffer. For these reasons, engineering research has recently focused on fouling.

This paper presents evidence relating evaporator feed composition to fouling rate. Since the evidence was collected from various types of evaporators, we infer that these effects are applicable regardless of design or mode of operation of the evaporator.

The composition of deposits on the walls of tomato evaporators was much higher in protein but otherwise the same as the feed composition. Pretreatments which tended to rupture cells increased fouling. The retention of pectin quality also increased fouling. Allowing some preliminary fouling tended to reduce later fouling.

EXPERIMENTAL, RESULTS, AND DISCUSSION

Foul composition. In order to determine the composition of tomato foul, the deposits on the inside walls of various evaporator tubes were collected. In some cases, the evaporators were conventional plant-scale models. Most of these units had concentrated tomato continuously for 6 days. The evaporators included forced and natural circulation types, and one and two-inch stainless steel tubes. The tomato feed to these evaporators ranged from 6% to 30% solids. After shutdown, the tubes had been washed by circulating water until there was no further color in the wash. Samples were then scraped off the inside walls near the ends of the tubes.

The wall deposits in a pilot-scale flash evaporator were also collected. These deposits had been formed inside a three-quarter-inch stainless steel tube after 1- to 2-hour runs on tomato juice or paste. In this case, samples were taken before and after water washing at various positions along the tube. The composi-

[a] Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, May 19, 1959, Philadelphia, Pennsylvania.

[b] A laboratory of the Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

tion of the foul did not depend significantly on the site of collection nor on water washing.

Average results on a solids basis are shown in Table 1. The only significant difference found between the foul and the feed from which it had been formed is the accumulation of protein in the foul. Interestingly, this is also true of grape juice. The foul from a tube in which red European grape juice had been concentrated was 25% protein, compared to 2% protein in the juice, both on a dry basis.

The microscopic appearance of the tomato foul is that of clotted tomato. Unclotted parts of the juice tend to adhere to the denser sticky film. Figure 1

TABLE 1

	Per cent of solids in foul	Per cent of solids in evaporator product
Crude fiber (5)	3.3	3.0
Ash (5)	6.2	7.8
Pectin (3)	4.0	3.1
Protein (5)	33.0	13.0

shows a photomicrograph of tomato foul in which tomato cells are seen partly surrounded by foul.

Effects of cell damage. Protein in tomato is primarily found inside cells. Massive cell destruction might tend to release the protein, which promotes fouling. Such cell destruction can arise from flash decompression or from milling, including inadvertent milling in pumps and finishers. To investigate this possibility, the effects of flash decompression on fouling were observed. In this process, tomato macerate is heated under pressure by steam injection. The pressure is suddenly reduced, causing vaporization of a part of the water. This process apparently ruptures many cells and causes general microscopic damage.

Mild decompression was caused by a flash through 40°, cooling to 215° F. after a 0.1-second hold at 255° F. More severe decompression was caused by a flash through 60°, cooling to 215° F. after a 20-second hold at 275° F. The effect of the pretreatments is

Figure 1. Tomato foul (x 15)

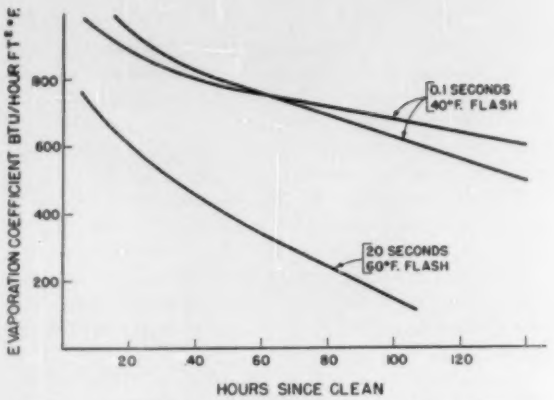

Figure 2. Effect of heat treatment on fouling of tomato macerate.

shown in Figure 2. These data represent changes in evaporation coefficients during continuous 6-day operation. Points for the three curves were based on the same evaporators used in the same way during approximately equivalent weeks in successive seasons. The macerate was fouling the inside of a 1½-inch stainless steel tube, about 21 feet long. The curves contrast the slower fouling following the mild decomposition with the more rapid fouling after the more severe decompression. The pair of runs with the milder decompression show good mutual agreement.

Effects of separate feed components. Since flashing or milling pretreatments affect all components of tomato, we wished to determine which change affects fouling. Therefore the fouling effects of individual components were tested in a pilot model flash evaporator (4). This was done by making up a synthetic mix, similar to tomato in respect to fouling rates, at least at one evaporator condition. The material used is shown in Table 2, compared to the composition of skinned and cored fresh tomatoes.

The sugar in the synthetic was sucrose; the insoluble fiber was wood flour; protein was egg albumen; ash was principally potassium chloride; pectin was low methoxyl, citrus pectin; acid was hydrated citric acid; and the organic salts were mainly citrates necessary to adjust the pH to 4.3. The synthetic had a consistency very similar to that of tomato, measured by a Stormer viscosimeter.

Fouling effects were studied during atmospheric evaporation of the liquids flowing downward at a mass velocity of 35 lbs. per second per square foot inside a

TABLE 2

	Per cent of solids in tomatoes (2)	Per cent of solids in synthetic
Sugar	54.0	53.0
Insolubles	15.0	14.0
Protein	13.0	14.0
Ash	7.8	8.4
Pectin	3.1	3.6
Acid	5.1	5.0
Organic salts	2.0	2.0
	100.0	100.0

six-foot section of ¾-inch stainless steel tubing which was surrounded by 335° F. steam.

Average fouling rates are shown in Figure 3 for replicated runs for both the total synthetic and for fresh tomato juice. Under the severe conditions used, the agreement between the full synthetic and tomato is good for short runs. More elaborate experiments, still to be reported, suggest that fouling under mild conditions can be studied by observing fouling under severe conditions.

First one and then another component in the synthetic was omitted or varied. The effects are compared to the full synthetic and to tomato in Table 3. The results show the adverse effects of protein as well as

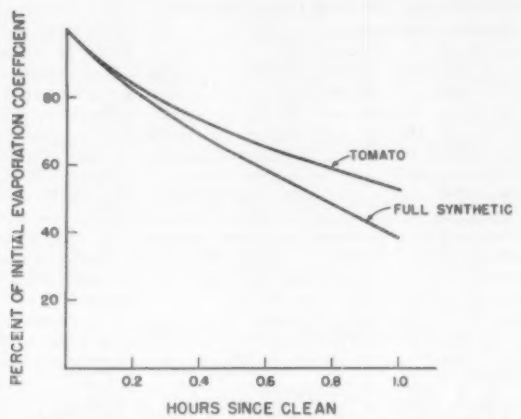

Figure 3. Comparison of fouling of synthetic and tomato juice.

the expected influences of pectin and fiber on fouling.

Pectin and fiber seem to affect fouling through their marked effects on consistency *(6)*. Consistency is not greatly affected by protein; therefore the protein may actually enter the fouling reaction. Since milling or flashing can reduce fiber size as well as release protein, 100-mesh wood flour was substituted for the 200-mesh flour usually used. The effect of finer fiber seems to be less detrimental, so that the adverse effects of milling may arise mainly from protein release. The very abrupt increase in fouling with the coarser fiber is probably not representative of tomato evaporation, but we infer that it is a qualitative indication of the effect of fiber size.

Effects of previous evaporation. Adams *(1)* suggested that fouling tendency is reduced by more intense heat treatment. The reverse appears to be true of the evaporator immediately following the heat treatment of tomato macerate. Subsequent evaporators, which concentrated finished juice to paste, fouled less rapidly with the intense macerate heat treatment than with the milder treatment. This improvement may be due to the fouling itself, which had

TABLE 3

	Evaporation coefficient after 30 minutes as per cent of initial evaporation coefficient
Tomato juice	72
Full synthetic	67
Synthetic without fiber	98
Synthetic without protein	90
Synthetic without pectin	92
Synthetic with coarser fiber	43

increased in the first evaporator. For this reason, 7% tomato juice was evaporated to 12% solids in the model evaporator. It was then diluted back to 7% solids and re-evaporated under the same conditions. Results are shown in Table 4. Clearly, the previous

TABLE 4

	Evaporation coefficient after 30 minutes as per cent of initial evaporation coefficient
First evaporation	72
Second evaporation	91
Third evaporation	94

evaporation and fouling reduced the ability of the juice to foul again.

SUMMARY

There is a selective accumulation of protein in the material fouling the walls of tomato evaporators. The foul is otherwise similar to tomato. Rupture of cells seems to increase fouling rates, probably by release of protein. Retention of pectin increases fouling. Use of a suitable surface for initial fouling might reduce fouling in subsequent heat exchangers, but severe heat treatment alone is not immediately beneficial.

Acknowledgments

Data was obtained by the cooperation of Thornton Canning Co. of Thornton, Calif. and Vie-Del Grape Co. of Fresno, Calif. Analyses were performed by Mr. Henry Wright and microphotography by Dr. Roger Reeve.

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Slurry Viscosity Measurements as Methods to Determine Maturity of Lima Beans and Peas[a, b]

(Manuscript received May 21, 1959)

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MATURITY DETERMINATIONS of lima beans and peas are widely used by food processors for pre-testing, basis of payment, yard segregation, and quality control. In general, these determinations involve mechanical procedures which measure resistance to shear, compression and/or puncture *(5, 6, 7)*. Cost of these mechanical devices is becoming increasingly limiting, however, and there is a need for a less expensive procedure for determining vegetable crop maturity. Accuracy, precision, and versatility must not be sacrificed, of course, in the process.

Slurries of macerated vegetable tissues and water, which are considered "non Newtonian" in nature, have been observed to exhibit widely different rheological properties. The viscosity of slurries made from immature lima beans or peas is low whereas slurry viscosity from mature harvests is high. The increase in viscosity is apparently due to an increase in the per cent alcohol insoluble solids (A.I.S.) and a decrease in the moisture content in the limas and peas as they approach maturity.

Viscosity measurement of slurries can be accomplished by rotational, limit of flow, falling body and rate of flow techniques. Earlier work by Elehwany and Kramer *(3)* reported the use of a rotational device, the Stormer viscosimeter, to determine average canned pea quality. They considered the method to be of promise as a quick procedure to predict per cent A.I.S. of canned peas.

The three-year study herein reported was undertaken (1) to compare the efficency of the rotational and the limit of flow techniques of measuring slurry viscosity, (2) to develop a standard procedure for ascertaining the rheological properties of raw, blanched, canned lima beans and peas, and (3), with the development of a standard procedure, to determine its accuracy in predicting finished product quality and its precision in relation to other objective maturity measurements.

MATERIALS AND METHODS

The raw lima beans and peas for this 3-year study were grown at the Horticulture Plant Research Farm; commercial samples, prepared by Coastal Foods Co., were grown on the eastern shore of Maryland. The beans and peas were harvested and processed according to the schedule presented in Table 1.

The raw, blanched, canned lima beans and peas were evaluated for viscosity differences according to the schedule shown in Table 2.

Techniques for viscosity measurements

Stormer Viscosimeter. The canned beans were drained for 2 minutes on an 8-mesh screen. One hundred grams of beans were blended with 100 ml. water for 4 minutes in a standard Waring blender at 15,000 r.p.m. The slurry was immediately placed in the Stormer cup. A 106 g. weight falling about 40 inches caused the cylinder to rotate in the slurry. The pointer on the counter was placed 10–20 revolutions to the right of zero to insure uniform speed before the timing period began. With a stopwatch ready, the brake was released; the watch was started exactly at the time the pointer passed zero of the dial and stopped exactly when the pointer again passed zero. This procedure registered the time of 100 revolutions. Temperatures were recorded. Four readings were made on each sample and were reported in seconds required for 100 revolutions.

Brookfield Rotational Viscosimeter. Two hundred grams of drained beans were blended with 200 ml. of water in a standard Waring blender at 15,000 r.p.m. The actual measurement was as follows:

1. The blended slurry was placed in a 400 ml. beaker.
2. The Brookfield was leveled and clamped solidly for the test.
3. The pointer was returned to zero.
4. The blend was allowed to settle for 15–17 minutes.
5. The pointer brake was held on and the Brookfield started.
6. Two turns were allowed at 30 r.p.m. with spindle No. 2 while holding brake.
7. The brake was released and three complete revolutions were allowed.
8. The brake was put on, the Brookfield stopped and the reading was made. 10 to 12 readings were made at each maturity level. Results were reported in centipoises.

Adams Consistometer *(1)*. Duplicate samples of raw, blanched, canned lima beans and peas according to weights, ml. of water and blend times presented in Table 2 were macerated in a standard Waring blender at 15,000 r.p.m. The temperature was recorded and the smooth homogenous slurry was poured immediately into the cone of an Adams Consistometer. The cone was released from the leveled plate and the spread or viscosity of the slurry was recorded after 30 seconds by averaging readings at 4 points around the plate. Results are reported in number of ¼ in. increments of spread or flow.

Other quality measurements

Shear-press. Maximum pounds force and the area in square inches under the work curve of the recording Shear-press were determined in duplicate on the raw lima beans in 1957. In 1958, maximum pounds force was determined on raw lima beans and peas. Shear-press readings for peas were converted to tenderometer values by dividing the pounds force value by a factor of 5.7.

Alcohol insoluble solids. Duplicate per cent alcohol solids (A.I.S.) were determined for all canned samples *(2)*.

Organoleptic evaluation. In 1957 an organoleptic maturity evaluation was made on the canned lima beans. The judges used a 1–10 scale, on which they considered 10–9–8 Fancy, 7–6–5 Extra Standard, 4–3–2 Standard and 1 Sub-standard.

[a] Presented at the 19th Annual Meeting of the Institute of Food Technologists, May 20, 1959, Philadelphia, Pennsylvania.

[b] Scientific Article No. A791, Contribution No. 3059 of the Maryland Agricultural Experiment Station (Department of Horticulture).

TABLE 1

Raw commodity handling and processing

Season	Commodity	Varieties	Harvests	A.I.S. range	Blanch		Process	
					Temp.	Time	Temp.	Time
				(%)	(°F.)	(min.)	(°F.)	(min.)
1956	Lima beans	3	5	18.6 –27.3	200	3–5	245	27
1957	Lima beans	13	5	14.1*–25.8	200	3–5	245	27
1958	Lima beans	4	5	16.5 –26.5	200	3–5	245	27
1958	Lima beans	....†	..†	.....†	.....†	.....†	.....†	....†
1958	Peas	4	5	8.1 –20.6	200	2–5	245	26

* Low per cent A.I.S. due to Baby Fordhook.
† Commercial Pack, 91 Samples, Coastal Foods, Cambridge, Maryland.

TABLE 2

Viscosity measurements of experimental samples

Season	Commodity	Technique	Instrument	Viscosity range	Slurry preparation		
					Commodity	Water	Blend
					(wt. g.)	(ml.)	(time min.)
1956	Canned lima beans	Rotational	Stormer	40–60 sec./100 rev.	100	100	4
	Canned lima beans	Rotational	Brookfield	30–80 centipoises	200	200	4
	Canned lima beans	Limit of flow	Adams	4–17 ¼" increments	250	100 to 225 in increments of 25 ml.	4
1957	Raw lima beans	Limit of flow	Adams	minus 1 to +12 ¼" increments	300	150	5
	Canned lima beans	Limit of flow	Adams	1–7 ¼" increments	300	250	5
1958	Raw lima beans	Limit of flow	Adams	minus 1 to +12 ¼" increments	300	150	5
	Blanched lima beans	Limit of flow	Adams	0–7 ¼" increments	250	400	5
	Canned lima beans	Limit of flow	Adams	1–6 ¼" increments	300	250	5
	Raw sweet peas	Limit of flow	Adams	minus 3 to +12 ¼" increments	300	150	5
	Blanched sweet peas	Limit of flow	Adams	minus 3 to +11 ¼" increments	250	150	5
	Canned sweet peas	Limit of flow	Adams	0–11 ¼" increments	300	200	5

RESULTS AND DISCUSSION

Stormer Viscosimeter. Results using the Stormer to measure viscosity are presented in Table 3.

Although there was a fairly high positive correlation between the Stormer readings and the per cent A.I.S., the high standard deviation among 4 Stormer values per sampling indicated this instrument was not precise enough to measure the per cent A.I.S. of canned lima beans. Elehwany and Kramer *(3)* reached similar conclusions concerning the lack of precision of the Stormer viscosimeter to measure the viscosity of canned pea slurries. Since this technique was not precise and there were inherent practical difficulties in operating this instrument it was decided not to study this procedure further.

Brookfield Viscosimeter. Results using the Brookfield viscosimeter to measure viscosity are presented in Table 4.

Data in Table 4 shows the Brookfield will not predict accurately the per cent A.I.S. Viscosity did not increase as the per cent A.I.S. increased in beans of late harvests. The standard deviation of 10–12 readings on each individual treatment was high. On the basis of poor accuracy, precision and inherent practical difficulties in the procedure, it was decided not to study the Brookfield further.

Adams Consistometer. *1956 Season—Lima Beans.* In 1956 some exploratory work was conducted with this limit of flow technique. Table 5 shows the great range of flow found with varying dilutions of canned beans and water. This method although not tested in 1956 over a full maturity range showed promise because the blended mass flowed smoothly and evenly on the Adams plate. The procedure was simple and practical to operate. Varying dilutions of beans and water gave progressively wider flow areas directly proportional to the dilution. It was decided to test this technique under a wide range of conditions.

1957 Season—Lima Beans. In this season raw and canned lima beans over a wide range of maturity conditions were studied. Important relationships in this study are presented in Table 6.

TABLE 3

Mean values and standard deviations for Stormer values and per cent A.I.S.—Canned lima beans

Variety	Stormer	Std. deviation	A.I.S.	Std. deviation
	(sec./100 rev.)		(%)	
Fordhook 242				
Harvest 1	40.25	6.98	20.34	.11
Harvest 2	44.75	8.56	22.20	.10
Harvest 3	54.25	11.40	24.30	.05
Harvest 4	58.75	7.26	25.93	.05

Results showed a high positive relationship between all factors studied. The correlation coefficient between canned slurry viscosity and per cent A.I.S. of canned lima beans was somewhat lower than the rest and this was probably due to the restricted range in canned products.

Maturity evaluation by the panels showed the lima bean maturity levels ranged from fancy to standard. Breaking points between the grades are suggested in terms of slurry flow, shear-press and per cent A.I.S. The break point between fancy and extra-standard was a slurry flow of 5, a shear-press 1200, and a per cent A.I.S. of 21 and between extra-standard and standard a slurry flow of 9, a shear-press 1500 and a

TABLE 4

Mean values and standard deviations for Brookfield and per cent A.I.S.—Canned lima beans

Variety	Brookfield	S.d. deviation	A.I.S.	Std. deviation
	(centipoises)		*(%)*	
Henderson		9.42	22.68	.12
Harvest 1	49.50	11.73	24.22	.05
Harvest 2	54.55	10.76	25.78	.11
Harvest 3	42.20			
Harvest 4	41.50	6.20	27.33	.10
Fordhook 242				
Harvest 1	60.55	5.24	20.34	.11
Harvest 2	68.15	5.65	22.20	.10
Harvest 3	42.20	10.33	24.30	.05
Harvest 4	50.30	8.14	25.93	.05

per cent A.I.S. of 24%. No samples were over 25.8% A.I.S. so a breaking point between the standard and sub-standard grade was not determined.

1958 Season—Lima Beans. Relationships between the various quality measurements are presented in Table 7.

It may be concluded from Table 7 that there was again a close relationship between slurry viscosity,

TABLE 5

Flow characteristics of canned lima bean slurries diluted with water

250 gram beans with	Flow ¼" on Adams
100 ml. H_2O	17.0
125 ml. H_2O	16.5
150 ml. H_2O	14.2
175 ml. H_2O	12.5
200 ml. H_2O	11.3
225 ml. H_2O	4.0

shear-press values and per cent A.I.S. of the canned beans.

Figure 1 shows the relationship between raw slurry viscosity for the 1957 and 58 seasons and the per cent A.I.S. of canned beans. This correlation coefficient for data from the two seasons was +0.914. Also included are the regression lines between the per cent A.I.S. and slurry measurements of blanched and

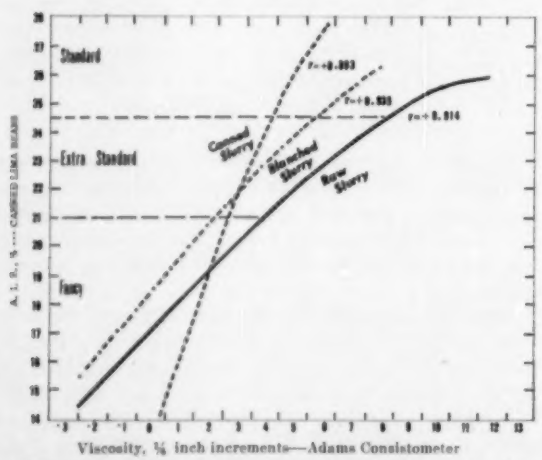

Figure 1. Relationship between lima bean slurry viscosities and per cent A.I.S. of canned lima beans.

canned beans. Raw and blanched slurry measurements can be used quite successfully to predict the maturity of the canned product. The canned slurry measurements did not exhibit the accuracy shown with the raw and blanched products but appeared promising as a quick way to determine the per cent A.I.S.

Figure 2 shows the relationship between raw slurry determinations and shear-press. The shear-press and raw slurry viscosity determinations were very closely related. Each should be an equally good index of raw bean maturity.

TABLE 6

Correlation coefficients between slurry viscosity, shear-press and per cent A.I.S. of lima beans—1957 season

	A.I.S.	Raw slurry viscosity
Raw slurry viscosity	+0.928	.....
Canned slurry viscosity	+0.737	+0.943
Shear-press		
Lbs. force	+0.934	+0.947
Area sq. inches	.....	+0.924

It has been established that the limit of flow technique to measure maturity of lima beans is accurate in predicting canned product maturity. The precision of the technique should also be compared with another objective measurement. Raw slurry viscosity has been chosen for this comparison. This has been done by determining the pooled standard deviation of duplicate raw slurry viscosity determinations and the shear-press readings in pounds force and expressing them in terms of change in per cent A.I.S.

Table 8 shows that on a per cent A.I.S. comparison basis the shear-press deviation accounts for slightly less change in per cent A.I.S. than does the raw slurry viscosity. Thus the two tests were approximately equal in precision.

The pooled standard deviation for blanched lima bean slurries was also very low ±.18, ¼ inch units.

1958 Season—Commercially Packed Lima Beans. Raw slurry viscosity of 91 commercially packed samples at Coastal Foods showed the following results. There was −0.953 correlation coefficient between raw slurry viscosity and U. S. maturity grade scores assigned by company graders to canned beans. Temperature of the slurry was correlated with the amount of raw slurry flow. This correlation coefficient (−0.163) was not significant and showed if samples were in the temperature range of 85–100° F., the temperature had very little effect on viscosity.

TABLE 7

Correlation coefficients between slurry viscosity, shear-press and per cent A.I.S. of lima beans—1958 season

	A.I.S.	Raw slurry viscosity
Raw slurry viscosity	+.905	.....
Blanched slurry viscosity	+.935	.....
Canned slurry viscosity	+.881	.....
Shear-press		
Lbs. force	+.951	+.957

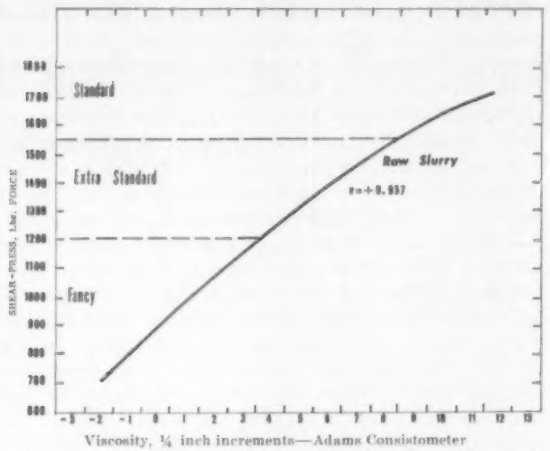

Figure 2. Relationship between raw lima bean slurry viscosities and shear-press determinations.

1958 Season—Peas. Table 9 presents the important correlations between raw, blanched and canned slurry viscosity and other important maturity tests.

Results showed a high degree of accuracy in predicting the per cent A.I.S. of canned peas from slurry viscosity determinations. Data for Alaska peas are not included because of the small number of samples but the slurry viscosity measurements are obviously applicable for Alaska peas.

Figure 3 shows the regression lines between raw, blanched and canned sweet peas viscosity and the per cent A.I.S. of the canned product.

It is apparent from the data in Figure 3 that the accuracy of predicting the per cent A.I.S. of canned peas from slurry viscosity determinations of the raw, blanched or canned product was good.

Figure 4 shows the relationship between raw slurry determinations and tenderometer readings on raw peas.

The close relationship between tenderometer readings and raw slurry flow indicated these two tests could be used interchangeably.

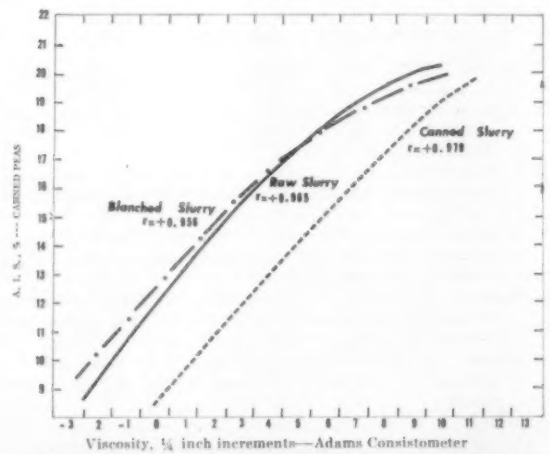

Figure 3. Relationship between sweet pea slurry viscosities and per cent A.I.S. of canned peas.

TABLE 8

Precision comparison of slurry viscosity and shear-press lbs. force on raw lima beans—1958 season

	Raw slurry flow	Shear-press
	(¼" units)	*(lbs. force)*
Pooled standard deviation	±.27	±18.45
Per cent A.I.S. change	0.5	0.4

The precision of viscosity measurements of raw slurries when tested against tenderometer values is presented in Table 10.

The precision of the raw slurry viscosity determinations and the tenderometer values on raw peas was equal in terms of per cent A.I.S. change. The pooled standard deviation for blanched pea viscosity was ± .32, ¼ inch units.

Additional considerations

Macerated, blended vegetable tissue and water slurries although homogeneous and smooth in nature contain considerable air. The amount of air whipped into the slurry during blending has not been measured or removed prior to viscosity measurement. These gases undoubtedly contribute to the thickness of the slurries. With this in mind it is of utmost importance to maintain a standard blending procedure and to make a viscosity determination immediately after the blending is over. Low standard deviations of duplicate samples show, however, this is not a serious problem if exact procedures are used. Blend times for this batch operation using the Adams Consistometer may be reduced to 2–3 minutes but undoubtedly new regression lines should be calculated for these different procedures.

TABLE 9

Correlation coefficients between slurry viscosity, tenderometer and per cent A.I.S. of peas—1958 season

Sweets	A.I.S.	Raw slurry viscosity
Raw slurry viscosity	+0.965	.....
Blanched slurry viscosity	+0.956	.....
Canned slurry viscosity	+0.979	.....
Tenderometer	+0.954	+0.973

It should be noted that the greatest use of this procedure may apply to raw and blanched commodities. The range of viscosity values for raw and blanched materials is greater than for canned products. In the canned product, the range of per cent A.I.S. is probably reduced from that in the raw or blanched product. This reduction could be caused by greater absorption of liquid in canned samples of advanced maturity. It is possible also that smaller amounts of intercellular air in canned products may account for lower ranges. Blanching times and temperatures have also affected viscosity measurements. Processors should adjust their values according to their respective blanch times and temperatures.

If this technique is to become practical as a maturity measurement for vegetable products, a stronger

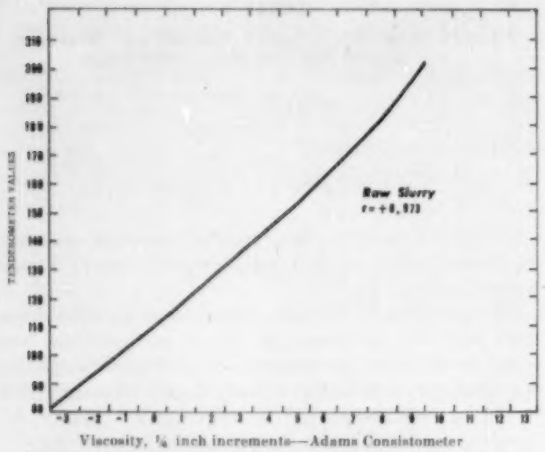

Figure 4. Relationship between raw sweet pea slurry viscosities and tenderometer values.

and more versatile blender must be used. Mature lima bean and pea samples have caused a slowing of the blender blades in the standard Waring blender from 15,000 r.p.m. to speeds somewhat lower. This may account for the non-linear increases in viscosity at the advanced maturity levels. Thus to insure proper blending, blender cup size, shearing blade size and free running speeds must be carefully standardized so that all readings can be reported on an equal basis.

TABLE 10

Precision comparison of slurry viscosity and tenderometer values on raw peas—1958 season

	Raw slurry flow	Tenderometer
	(¼" units)	
Pooled standard deviation	±.19	±1.06
Per cent A.I.S. change	0.5	0.5

The present procedure developed on a batch basis for lima beans and peas but applicable for many other products should also lend itself to several almost continuous maturity measuring systems for in-plant use. For example, samples taken automatically from the processing lines, homogenized with water for 30–60 seconds, could be measured with a differential shear type flow bridge such as the Plastometer *(4)*. One such instrument should be able to record maturity of a number of lines depending upon the rapidity of measurements required. These procedures, of course, would greatly increase the cost of equipment over the simpler batch determination method.

SUMMARY AND CONCLUSIONS

Viscosity measurements have been reported as satisfactory methods to determine the maturity of raw, blanched, canned lima beans and peas. It is postulated that similar results will be found with the use of this technique on raw corn, snap beans, black-eyed peas and other products.

Of the techniques studied, a limit of flow method, using an Adams Consistometer has been most satisfactory. The equipment required for this measurement is versatile and reasonable in price. Correlation coefficients of 0.90 or better are reported between viscosity measurements, mechanical devices and chemical analyses of the canned product. Precision of the method was equal to such instruments as the Shearpress and Tenderometer when compared on a raw commodity basis, however, determination time by the viscosity method was approximately 6 minutes. Temperature of the slurries in an 85–100° F. range was not a significant factor causing variation in slurry viscosity values. Air whipped into the slurry during the blending operation was not measured or removed but may have an effect on viscosity values. It is thus important to follow a standard procedure for all viscosity determinations.

Recommended procedure for slurry viscosity determinations.

1. Weigh sample and add water to Waring blender cup according to instructions in the 1958 section of Table 2.
2. Blend the vegetable product and water together for 5 minutes at 15,000 r.p.m.
3. Empty slurry immediately into an Adams Consistometer cone.
4. Release the cone from the leveled plate and record the spread of the slurry after 30 seconds by averaging readings at 4 points around the plate.

The concept that slurry viscosity of vegetable tissues and water are closely associated with maturity will probably be fully exploited by the food industries when it is applied to an almost continuous recording in-line maturity measuring procedure.

Acknowledgment

The author would like to thank Ronald Bamford and John Mason who contributed a great deal of time and effort in analyses and tabulation of data.

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A Method for Screening Flavor Panel Members and Its Application to a Two Sample Difference Test*

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SCREENING AND FLAVOR test methods described in this paper were developed for the purpose of evaluating experimental container materials for canned beer. Potential flavor panel members were screened for sensitivity, or tolerance, to bitterness since this taste was considered a major component of beer flavor.

Flavor response varies from taster to taster. The characteristic response of each taster to bitterness was measured and the variation of these responses was used to establish statistical standards for interpreting flavor test results. The statistical foundation for the Two Sample Difference Test was reported in a previous paper *(5)*. The purpose of this current paper is to describe the screening method used to select panel members for the Two Sample Difference Method.

EXPERIMENTAL

Personnel screened. One-hundred fifteen members of the Container Development Group at Continental's Metal Division Research & Development Center were screened. Seventy-one of these people completed the screening tests. The individuals screened included technical and nontechnical persons of both sexes, representing a wide range in ages.

Screening method

Materials. Solutions of quinine sulfate were prepared in the following concentrations with double de-ionized water. A check of distilled water and double de-ionized water showed the double de-ionized water to be more flavor-free than the distilled water.

Identification sample	First dilution series	Second dilution series
12.5 p.p.m. (quinine sulfate)	(quinine sulfate)	(quinine sulfate)
	1.45 p.p.m.	0.10 p.p.m.
	2.15 p.p.m.	0.30 p.p.m.
	3.21 p.p.m.	0.90 p.p.m.
	4.83 p.p.m.	2.70 p.p.m.
	7.06 p.p.m.	8.10 p.p.m.

Procedure. *Identification Test:* All tasters were presented with an identified sample of double deionized water containing 12.5 p.p.m. of quinine sulfate. This level of quinine was selected as being easily recognized as having a bitter taste. Tasters were asked to familiarize themselves with the taste of this solution so that they might be able to identify the "taste" of an unknown sample to be served them at some future time.

Determination of the Applicable Range of Dilutions. Applicable range of dilutions is defined as that which would show the majority of the tasters as being sensitive to the middle dilutions.

First Series of Dilution Samples. The quinine concentrations used in the first series of dilution samples listed above were based upon those used by Mackey and Valossi *(3)*. Samples were arranged in order of increasing concentration.

Samples were sometimes preceded by 1, 2, or 3 blank samples i.e., double de-ionized water containing no quinine sulfate. No more than 5 samples were served at one session. High concentration samples were eliminated when water blanks were served. Tasters, therefore, had no indication of which sample contained the lowest concentration of quinine.

Each taster was asked to mark the dilution at which he first obtained a taste sensation with a plus sign (+) and to mark the preceding dilution with a minus sign (−).

Results of this series indicated that the range of concentrations was too high for the tasters being screened, as the majority of tasters indicated sensitivity to the lowest level.

Second Series of Dilution Samples. Presentation and serving of the second series was the same as the first series, except all concentrations were considerably lower.

This series provided the range of dilutions which would show the majority of tasters as being sensitive to the middle dilutions. A duplicate test was run one day later in order to check the precision of tasters in detecting a certain level of bitterness.

Selection of Tasters. The bitterness tolerance level for each taster was calculated as the geometric mean of the dilution at which he first obtained a taste sensation and the preceding dilution. This bitterness tolerance level was calculated separately for each of the duplicate tests for each person. The maximum and minimum dilution values for each person were plotted against the minimum to show the range of that person. (See Figure 1.) The tolerance levels of the individuals who showed no variation in their test results lie on the line of zero logarithmic range.

Fourteen of the tasters screened had participated in triangle difference tests over a two-year period. The percentage of times that each flavor tester correctly identified the odd sample of beer in triangle tests was plotted against his average sensitivity level to quinine sulfate as derived in this test. (See Figure 2.) A relationship between the ability of these tasters to identify

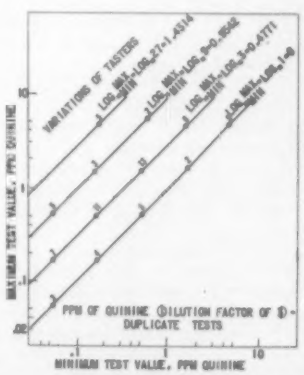

VARIATIONS OF TASTERS
MAXIMUM TEST VALUE, PPM QUININE
PPM OF QUININE DILUTION FACTOR OF 1.9 - DUPLICATE TESTS
MINIMUM TEST VALUE, PPM QUININE

Figure 1. Sensitivity of tasters to bitter taste.

* Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, Philadelphia, Pennsylvania, May 20, 1959.

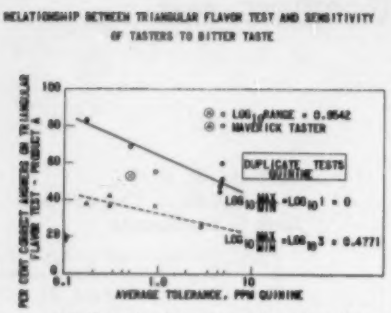


Figure 2. Relationship between triangular flavor test and sensitivity of tasters to bitter taste.

the correct odd sample of beer in a triangle test and their sensitivity level of quinine sulfate is indicated. The "precise group" of seven tasters with a zero logarithmic range correctly identified a larger percentage of odd samples in the triangle test than those tasters who were less precise on the quinine sulfate test. Within each precision group individuals who showed sensitivity to quinine sulfate correctly identified the odd sample more frequently than did those tasters who were less sensitive to quinine sulfate.

Based on this experimental evidence, 15 (out of the original 71) tasters with an average sensitivity level of 0.06–4.80 p.p.m. quinine sulfate and a zero logarithmic range were selected as potential panel members for the Two Sample Difference Test.

Flavor test method

Two sample difference test. *Panel Members:* 7–10 persons persons screened according to the above prescribed method.

Materials: For 10 panel members

80 — Red 3-ounce brandy snifters with watch glass covers
2 Qts. — Standard, or control samples
1 Qt. — Samples packed with Test Material "I"
1 Qt. — Samples packed with Test Material "II"

Beer samples were stored at 40° F. and served at 45°–50° F.

Procedure:

1. Coding of Samples:

Code	Number of 11-ounce samples	Description of samples
K	40	Standard or Control
L	10	Test Material "I"
R	10	Test Material "I"
S	10	Test Material "II"
T	10	Test Material "II"

2. Test Situation: Description of tray served to taster:

Pair 1	K — L	(Identical Samples— L and R, S and T)
Pair 2	K — S	
Pair 3	K — R	
Pair 4	K — T	

One standard sample "K" was paired with each test sample. Each taster was served 4 pairs on one tray as shown above. Fatigue tests conducted with 7 pairs of beer samples indicated that tasters cannot discriminate accurately when more than 8 samples (4 pairs) are tasted at one sitting.

The standard "K" was placed to the left of the test samples so that it would be tasted first. Tasters were aware that sample "K" was the standard, but they did not know whether the test samples were actually duplicates of "K" (Section 5—"Standard-to-Standard" Ratings) or test material samples. Tasters were given information as to test medium, e.g. brand of beer, etc.

The pairing of code letters was randomized from test to test so that no two letters, e.g., "L" and "R," "S" and "T," would become associated as a pair. The order of samples served was randomized within each test so that no one test material was served first or last.

3. Panel Room: The taste tests were conducted in a panel room free of noise, odor and distraction. The instructions shown in Figure 3 were posted in each panel booth.
4. Flavor panel members were asked to record a difference rating for each pair of samples, Figure 4. The difference is recorded on a "0–5" scale with a grade of "0" indicating "no difference" and a grade of "5" indicating an extremely large difference. A quality score for each test sample compared with the standard sample was also recorded.
5. Determination of "Standard-to-Standard" Difference Rating: A pair of standard samples was periodically included in the test situation in order to check the performance of the panel members. THE TASTERS DID NOT KNOW WHEN THIS SITUATION WOULD OCCUR.

Description of tray served to tasters in standard-to-standard test:

INSTRUCTIONS

The samples before you are arranged in pairs. Each pair consists of a standard sample and a test sample and is to be evaluated independently of the other pairs. The glass marked "K" always contains the stanadrd sample for each pair. The glass marked "L," "T," "R," or "S" always contains the test sample.

Evaluate the First Pair ("K" and "L") as follows:

SNIFFING INSTRUCTIONS

1. Place your nose close to the top of the glass marked "K."
2. Carefully slide the watch crystal across the top of the glass to make a small opening. (Do not remove the watch crystal entirely.)
3. Re-cover the glass with the crystal in case you wish to check the odor again.
4. Repeat this procedure with sample "L." Note any differences in odor between samples "L" and "K."

TASTING INSTRUCTIONS

1. Remove the watch crystal and taste sample "K" slowly and carefully.
2. Rinse your mouth with water, or at least wait a minute or two before tasting sample "L." (Rinsing is optional, but if you rinse before one sample, please rinse before all samples.)

RECORD YOUR IMPRESSIONS OF ODOR OR FLAVOR DIFFERENCE AS FOLLOWS:

1. Circle the horizontal line (under "L") which best describes the degree of difference (if any) between "L" and "K." Decision may be based on either odor or flavor or both.)
   (a) If you did not find a difference between "K" and "L," it is not necessary to record any further information under "L." Go on to the next pair of samples.
2. Check the quality description which best describes "L" as compared to "K."
3. Comment on any unusual flavor or odor notes which you can detect in "L."
4. Check the appropriate box which tells whether any difference between "K" and "L" is based on odor or taste or both.
5. Circle the quality description which best fits the quality of the standard circle. Comment on any unusual flavor or odor notes which you can detect in "K."

Evaluate the remaining pairs of samples according to the above procedure. Please evaluate the pairs in the order in which they are presented.

Figure 3.

NAME _____ DATE _____ TIME _____

DIFFERENCE

	SAMPLE L	SAMPLE T	SAMPLE R	SAMPLE S
NO DIFFERENCE	0	0	0	0
	0.5	0.5	0.5	0.5
VERY SLIGHT DIF.	1	1	1	1
	1.5	1.5	1.5	1.5
SLIGHT DIF.	2	2	2	2
	2.5	2.5	2.5	2.5
MODERATE DIF.	3	3	3	3
	3.5	3.5	3.5	3.5
LARGE DIFFERENCE	4	4	4	4
	4.5	4.5	4.5	4.5
EXTREMELY LARGE DIFFERENCE	5	5	5	5
THE QUALITY OF THE TEST SAMPLE IS:				
INFERIOR TO K				
EQUAL TO K				
SUPERIOR TO K				
COMMENTS:				
DIFFERENCES BASED ON:				
ODOR				
TASTE				
TASTE & ODOR				

STANDARD SAMPLE (K)

QUALITY OF SAMPLE K IS: (CIRCLE ONE)
EXCELLENT
GOOD
FAIR
POOR

COMMENTS

Figure 4.

Pair 1	K — L
Pair 2	K — K
Pair 3	K — R
Pair 4	K — K

(Identical Samples—L and R—a test material, all K's)

Samples were randomized as in the test situation with two test materials.

It was not necessary to run a standard-to-standard pair in each test, but this rating had to be determined for each product and for each variation of a product, e.g., brand of beer. The average standard-to-standard rating appeared to be constant for a particular product. This rating was checked for each storage period, but not necessarily in each testing session.

6. Evaluation of Test Results:

a. The difference rating determined for the first pair, composed of a standard and a test sample, was plotted against the difference rating determined for the second or duplicate pair. The graph shown in Figure 5 was used. This graph was calculated according to a control chart method as used for evaluating the difference between duplicate chemical analyses.

The results of those tasters who were out of range on this graph were discarded since for that day they did not show the required degree of reliability. This step resulted in a panel of similar and sensitive tasters and under these circumstances the comparison of averages was valid.

b. The difference ratings of the tasters not discarded in step 1 was averaged for each test material.

c. The "chance" or "guessing" line was determined (Figure 6). This was the average difference found in the standard-to-standard test. Steps 1 and 2 must be followed when calculating this average difference for a standard-to-standard test. Tasters falling out of range on the identical sample test should be eliminated from taste panels on that particular product.

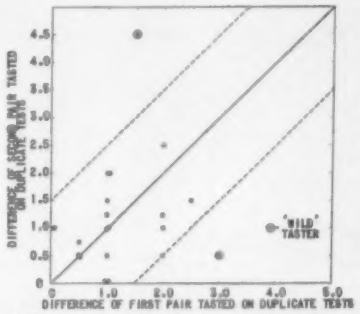


Figure 5. Range chart to detect "wild" flavor tasters on duplicate tests.

d. The average difference ratings for each test sample, as determined by steps 1 and 2, were plotted on the chart with the chance line. The significance of the results were determined by calculating the difference between the chance line and the average difference rating for each test material, and using a table based on the analysis of variance given in a prior paper presenting the statistical foundations of this method *(5)*. Each laboratory must determine its own specific table until such time as inter-laboratory studies show that one table is not specific.

e. The over-all quality rating of the test material as compared to the standard sample was determined by summarizing the quality ratings of those tasters whose results were valid; i.e., the quality ratings of those tasters discarded in step 1 were disregarded.

DISCUSSION

Test results

By using persons of known sensitivity to bitterness and the Two Sample Difference Method it is possible to separate the "flavor difference" into several components as described in another paper *(5)*. These components are as follows: (See Figure 7)

Material Flavor: This component is determined by the panel's ability to discriminate between experimental packaging materials. "Material Flavor" represents the effect of the test material other than bitterness upon the flavor of the food product.

Difference in Bitterness as measured by "Quinine Equivalents." This component is calculated by the

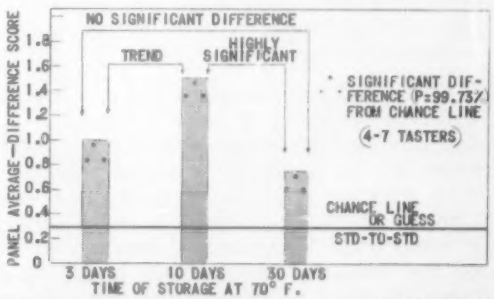


Figure 6. Results of a flavor test on an experimental container material.

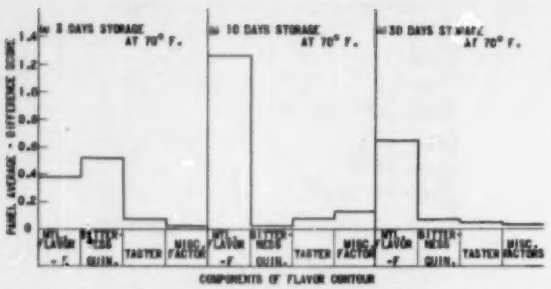


Figure 7. Continental flavor contours: flavor test on an experimental container material.

statistical methods of correlation and regression from the pre-determined bitterness sensitivity level of each taster.

Difference in Tasters: This component is the variation from taster to taster when no real difference exists in the test medium. It is determined by the standard-to-standard test for each medium.

Miscellaneous Factor: That difference in flavor remaining after separation of the above components. This component may include psychological and/or physical factors not specifically measured.

The method described in this paper for bitterness, measured as the quinine sulfate equivalent, may be used with other taste and flavor notes. By screening persons for sensitivity to materials it is possible to determine the amount of flavor difference that is associated with a taster's sensitivity to a particular material. It is then also possible to analyze a flavor difference for more than the 4 components shown in Figure 7 since the effect of the material is then determined directly according to the taster's sensitivity rather than by subtraction.

The following restrictions apply to this method of flavor analysis:

1. This method does not analyze the over-all flavor of a food product, but only that part of the flavor which makes a test sample different from a control sample. The flavor *difference* is analyzed, not the over-all flavor of the food product.
2. The test sample medium and the standard sample medium must be identical except for the addition of a test material to the medium.
3. This method can be used to analyze more than 4 components of a flavor difference, but there will always be a component, however small, due to remaining or "unknown" factors.

This method has been found satisfactory when dealing with concentrations of materials greater than those actually used in commercial practice, i.e., where differences are of a greater magnitude than they would be in actual practice. When expected differences are of a lesser magnitude, or equal to those which would occur in commercial practice, the test method and evaluation of results are modified. The experimental design is changed in that only one variable is evaluated per testing session and a standard-to-standard set is included within each test situation.

The resulting difference scores are those scores found by subtracting the standard-to-standard score from the score for the variable. The final scores are evaluated by statistical methods using sensitivity graph paper, or more formally, by an analysis of variance method *(5)*.

Test methods

The sensitivity of tolerance, of an individual taster to a basic taste was used as a screening device because of the simplicity of isolating the response to that taste. Success with this screening method has led to a program for the determination of individual taster response to specific flavor notes related to packaging materials.

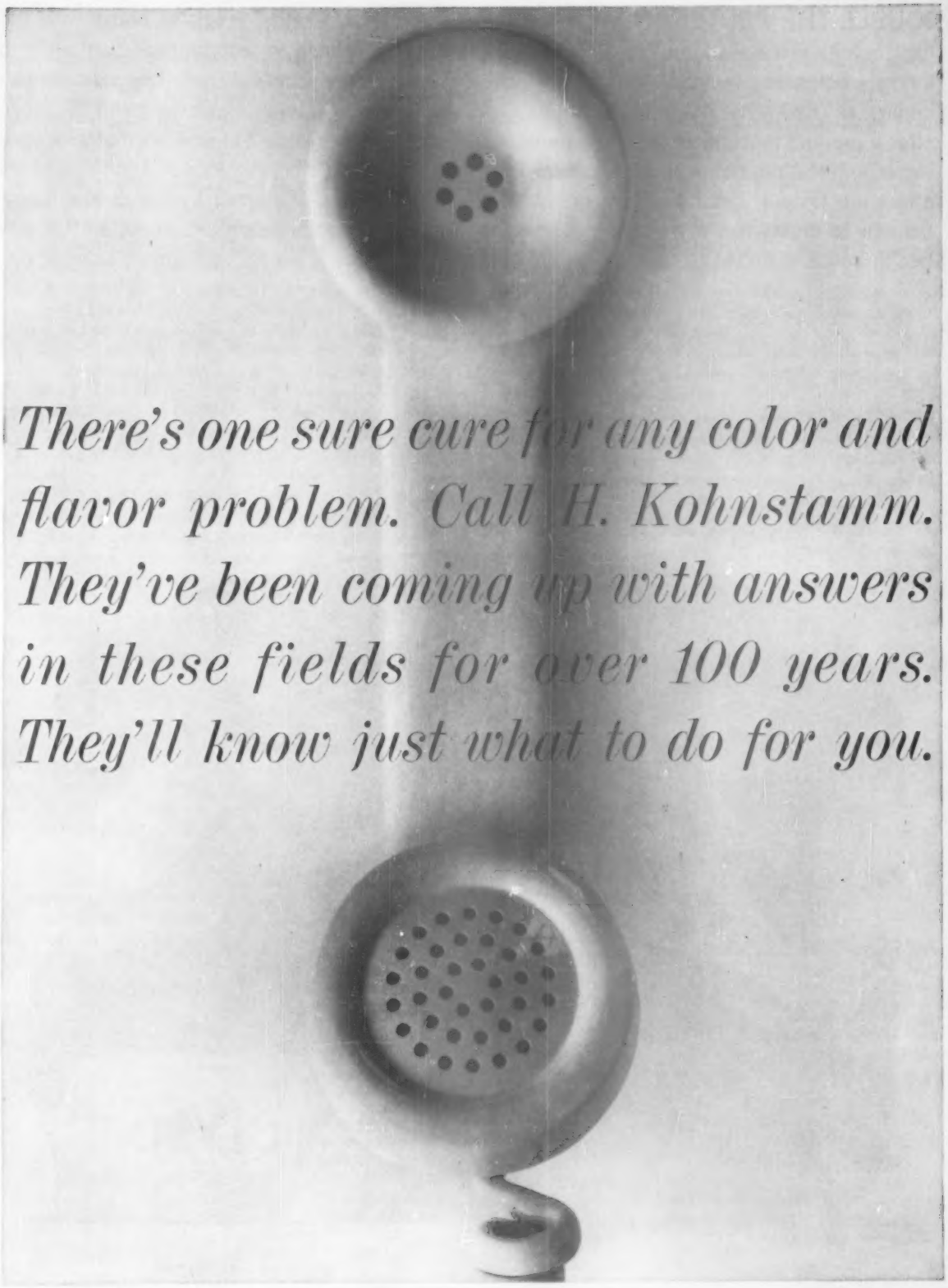
For any specific flavor tolerance screening a standard procedure is followed. In the first tasting session the potential experts are served an identified flavor at a concentration which can be easily recognized by most persons. In the next tasting session the tasters are served various dilutions of the flavor in ascending order of intensity. These dilutions are selected arbitrarily but must be in a logarithmic series because subjective judgment of flavor is proportional to the logarithm of the stimulus. Prince and Ince have indicated that this principle was the basis for their study of odor response *(4)*.

If the particular series of dilutions used proves to be suitable for the persons tested, then no further dilution series are necessary. If the series is not suitable, then additional series must be tried until one is found which covers the range of the tasters. The flavor experts for the Two Sample Difference panel are selected on the basis of their sensitivity to low concentrations and their reliability in reproducing this sensitivity.

The Two Sample Difference Test described in this paper is designed to measure the amount of difference between samples rather than indicating only that a difference between samples does exist. The triangle test is a qualitative test indicating that a difference may exist without measuring the degree of difference. This test suffices when no additional quantitative information is required. When considering packaging material and taster sensitivity, it is necessary to have a test which is quantitative as well as qualitative. The Two Sample Difference Test is designed to give this information.

The Two Sample Difference Test is basically a paired comparison test such as described by Byer and Abrams *(1)*. Each test sample is served in a pair with a standard sample. The standard sample is known or identified. The taster is asked to determine whether or not a difference exists between the two samples. The difference is recorded on a "0–5" rating scale with a grade of "0" indicating "no difference" and a grade of "5" indicating an extremely large difference. A duplicate set of samples, a known standard plus a test sample, is judged at the same session in order to check the accuracy of the taster's judgment.

Another check on the taster's reliability is the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standard-to-standard test. In this test duplicate standard samples are run instead of a standard and a test variable. Tasters do not know when the standard-to-standard tests will be run. Since there is a psychological factor in human beings which makes them think there *is* a difference if the possibility of a difference is suggested, some measure of this factor must be made. Serving two identical samples in the same pair at an undetermined time is a measure of this "factor." The difference rating assigned the standard-to-standard pair by any taster must be subtracted from his recorded difference score for the test materials.

In addition to assigning test samples a difference score, tasters are asked to describe the flavor quality of the test sample as being superior, equal, or inferior to the identified standard sample. If a difference is found to exist, the quality of the test sample can be evaluated.

Real differences between two experimental packaging materials may be determined by indirect comparison of the test results even though the two materials were not compared experimentally. This fact is a fundamental principle of the Two Sample Difference Test since a paired difference test automatically produces an orthogonal comparison. This orthogonality is not found with other types of difference testing such as the triangle test. Carlin, Kempthorne and Jordan give supporting evidence that this two sample difference comparison is valid *(2)*.

The Two Sample Difference Test as described in this paper is useful in the determination of "subtle" flavor differences which have not been determined by "rougher" multiple sample tests.

Packaging materials for beer are chosen for development based on the results of the above methods. Only those materials which are shown to be similar to the flavor-free standard sample are considered for potential commercial use.

SUMMARY

A method for screening potential taste panel members according to their sensitivity and precision has been applied to a Two Sample Difference Test for use in selecting container materials. The screening method involves: selection of "available," interested, well-motivated, possible panel members; education of tasters to identified sample of specific taste (of flavor); determination of a range of concentrations suitable for the majority of the persons to be screened; determination of the sensitivity of individual persons to the specific taste (or flavor) by running the suitable range of concentrations on two different days; and selection of those persons who are sensitive to low concentrations of the specific taste (or flavor) and who can duplicate their sensitivity to this low concentration as potential "expert difference" panel members.

The Two Sample Difference Test as interpreted in this paper has the following requirements:

1. Tasters must be screened according to the prescribed method;
2. Difference is determined between a known standard and an unknown test sample run in duplicate;
3. Difference is recorded on a "0–5" scale with "0" indicating no difference and "5" indicating extremely large difference;
4. A difference score must be determined for each taster when the test sample and the standard sample are identical. This score must be subtracted from any score assigned to a test sample in order to obtain the "real" difference score.

The combined screening and testing methods provide a senitive procedure for analyzing flavor difference.

Acknowledgment

The authors wish to express their appreciation to Dr. B. H. Morgan, Dr. R. E. Henry, and Mr. J. N. Demsey for their assistance in the course of this study. Appreciation is also expressed to Messrs. David R. Peryam and Norman F. Girardot for background information utilized in the preparation of this paper.

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Potential Economic Impact of Food Irradiation*

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(Manuscript received July 3, 1959)

ONE OF THE most encouraging features of irradiated foods today is that they are found only in experimental laboratories and on the menus of feeding experiments. You might ask, "Why wouldn't it be more encouraging to find them on our grocers' shelves?" The answer is that under the present state of the art and with present attitudes, it would be unfortunate indeed to attempt to market irradiated foods today. They would most certainly be a resounding failure. And those who might be so foolhardy as to try would surely find themselves involved in an economically disastrous venture.

Because irradiated foods are found only in our laboratories we can be assured that when they are launched they will have benefited from careful and searching scientific studies—and these studies will form the basis for commercial success.

To find people—food technologists in particular—still driving towards the goal of perfecting the irradiation process even in the face of great pessimism is most encouraging. A part of this pessimism may be warranted, but most of it is probably a psychological reaction to what was once a wave of optimism. Early reports made irradiation appear to be a panacea for all the weaknesses of our present food processing and storage system. Needless to say, in the wake of these glowing reports, food irradiation has been a great disappointment. But a look at the development of other innovations should dispel some of our fears.

A 15- TO 20-YEAR PROBATIONARY PERIOD

Historical evidence indicates that it takes from 15 to 20 years before a complex technological innovation has served its probationary period and reached general acceptance. Even such a technically simple innovation as frozen foods took 15 years to really get off the ground. Another example is that of radio. Experimentation in the propagation of radio waves was first started in 1886, but it wasn't until 1897 that Marconi was able to obtain the necessary capital to form an operating company. Even then, the company piled up deficit after deficit and didn't establish a sound financial footing until 1910 *(1)*. Thus, 24 years elapsed between the actual discovery of radio waves, and the time when the first company in the field was able to make money on the idea. On the basis of these examples, food irradiation isn't too far off schedule. The Quartermaster Corps did not institute its food irradiation program until 1953 and contracts were not let until 1954. Thus, no really concentrated effort was given to preserving foods by irradiation until a fairly recent date.

Somewhere around 1968, the cost factors may be well enough understood for the wise private enterpriser to exploit the invention. At that time we can expect irradiated foods to start appearing on our grocers' shelves. Such a schedule would give the process its full 15-year probationary period.

At present, one can easily become apprehensive because private enterprise has been rather hesitant in exploiting food irradiation. However, we should not be too critical of those who do not pursue a full-scale effort. Let us remember that the Federal Government has been funding the major part of development expenditures.

Under these circumstances, private enterprise may be somewhat reluctant to allocate large sums for research and development in food irradiation. Even so, it is to the advantage of the private enterpriser to cooperate with the Federal Government to the fullest extent consistent with the internal activities and policies of his own company. A private enterpriser in a position to take advantage of the new process should maintain a strong interest lest he be left behind when its worth is proven. By 1970 irradiated foods will have made the grade if they are ever going to—and if they do, entirely new concepts are going to be required in the processing, packaging, distribution, and marketing of foods.

PROMISE OF MAJOR ECONOMIC BENEFITS

Irradiation processing promises some major economic benefits that are well worth the efforts required to perfect the process. The benefits are dollar benefits running into the hundreds of millions annually. Savings will be made between farm and consumer in reducing food spoilage, transportation costs, storage costs, and in-store marketing costs.

Even though the capital outlay for installation of radiation sources will be high, there are companies in the food field which have the necessary financial resources to meet this challenge. And in view of the benefits to be gained, the investment will most likely be undertaken. Thus, with a successful launching, sales of irradiated foods should expand rapidly between 1970 and 1980.

* Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, May 19, 1959, Philadelphia, Pennsylvania.

Members of the food industry should watch the development of this process with great interest. However, such watchfulness should not be limited to the food industry alone. Other industries should remain keenly alert if they hope to take advantage of the potential of irradiated foods. Some of these nonfood industries are: manufacturers of food processing and packaging equipment, suppliers of packaging materials, producers of refrigeration units, and companies engaged in marketing, storage, and transportation of foods. The advent of food irradiation will create the need for innovating activities in these industries also.

A FACTOR IN THE FOOD FIELD BY 1980

Even if irradiated foods do not reach our grocers shelves for 10 more years, a look at 1980 reveals food irradiation as an important force in the food field—even when viewed by a conservative imagination.

Making a few assumptions and some calculated guesses, how much of a force can we expect? Let us assume that by 1980 irradiation can capture an average of 10% of the market in those food groups for which it appears to have promise. These would include fresh fruits and vegetables, fresh meats, potatoes, edible small grains, and those foods that are currently processed by thermal treatment and freezing. We can expect that over 200 billion pounds of foods falling in these groups will be consumed annually by 1980. Irradiation's 10% will amount to over 20 billion pounds and will be worth over $4 billion at current prices *(2)*. These figures exclude some large food groups such as fresh fish and poultry, dairy products, and fats and oils because competitive treatments, such as antibiotics, may prove superiority or because irradiation treatment shows little promise. But even though these groups are excluded, radiation could assume quite a stature. In 1980, it could be nearly two-thirds as large as either its stepfather, thermal, or its stepmother, frigid.

What sort of an impact will all of this have? Well, let us peer into the future and see how various industries will be affected.

First, let us look at the *food processing* industry. The likelihood is small that a distinct and separate segment of the food industry will arise as happened in frozen foods. Irradiation can most advantageously be utilized by those who are already processing foods; namely, the canners and freezers. Undoubtedly, this factor will further reduce the fresh produce packer's share of the total food market. Most packers of fresh produce are small and will be unable to meet the high capital costs of irradiation processing. Furthermore, these packers are not in the most advantageous technical position to exploit the new process.

The impact that radiation processing will have on the food processing industry will depend on the direction of development taken by the process. If its use in pasteurization treatment of fresh foods develops first, the frozen food processors are likely to hold an initial advantage. This follows from the fact that pasteurized foods still require refrigeration. The close alliance of frozen food processors to a well developed system of refrigerated warehouses makes them a natural for marketing pasteurized foods. Furthermore, their long experience in dealing with refrigerated foods gives them a managerial advantage over those canners who have not seen fit to enter the field of frozen foods.

Lest such *canners* lose hope, let us look further into the future. The trend in market behavior displays a strong consumer desire for an even wider variety of foods throughout the year. This should provide a strong motivating influence toward developing food products sterilized and preserved by radiation treatment. It also indicates that sterilization by radiation may ultimately become more important than pasteurization. Since sterilized foods need not be refrigerated, the canners may hold the long-run competitive advantage because of their alliance with the dry grocery distributor. Even so, those canners who have not entered the frozen food field may still find themselves at a disadvantage. They will not have gained technical background comparable to that of the frozen food processors who acquired technical competence in exploiting irradiation-pasteurization. Thus, such canners may find that they have entered the field much too late.

The *meat packers* form another segment of the food industry which will feel the impact of radiation processing. There will be a strong impetus toward precutting, prepackaging, and irradiating of meat at the packing plant. Perhaps the most important use for radiation in meat packing will be in the aseptic packaging of dry-cooked meats, such as roasts and steaks. All of this will provide packers with reduced transportation and storage costs. Also, the additional raw materials, forthcoming from meat and bone trimmings, can be sold as by-products such as ingredients for livestock feeds and fertilizers.

In the field of *food processing machinery*, manufacturers may be asked to develop new radiation resistant conveyors for passing foods through radiation chambers. Because packages of sizes and shapes differing from the present ones may be used, new packaging, labeling, and conveyor equipment will be required. For example, rectangular packages more efficiently utilize electron sources of radiation than standard cans. Thus, conveyors will be considerably different from those of today which rely heavily on gravity and a conveniently rolling tin can that conveys and labels itself.

IMPACT ON MARKETING, TRANSPORTATION, STORAGE

Radiation processing may foster a trend toward more centralized processing and integration of *marketing* functions. Because irradiation-pasteurization necessitates trimming and prepackaging, direct selling to retail chains will be further stimulated. This may shift even more of the responsibility of warehousing and storage back to the processor. Paralleling this shift there will be a diminishing need to find immedi-

ate markets for fresh produce because pasteurized foods will have a longer allowable storage life. These two factors will bring competitive pressures against fresh produce brokers and wholesalers. The longer storage life will also inject flexibility into handling market gluts of highly seasonal perishables.

Integration of production back to the farm may become more common. Irradiation will require more uniform quality of the raw product; and, in order to maintain this quality, processors will have a heavier hand in the production of the raw materials. This will make production a more predictable variable and should simplify inventory control. As soon as housewives become conditioned to shopping for this more uniform quality, other processed foods will follow this example. Thus, we can expect irradiation processing to cause an upgrading of quality all across the board.

Railroads and *trucking firms* should be able to achieve more orderly scheduling, and hence meet seasonal peaks with relatively less equipment. This follows because of the longer storage life of pasteurized foods. As compared to fresh produce, relatively less refrigerated transport equipment will be needed since a smaller volume of trimmed prepackaged foods will supply the market with an absolutely greater tonnage of edible food. This does not mean that growth in refrigerated transport equipment will stop—it means only that some leveling off can be expected. The higher value irradiated foods will be subject to somewhat higher transportation rates and will suffer fewer loss claims. Thus, the transportation industry may expect increased earnings from the transport of these agricultural commodities.

Industries which provide *packaging materials* to the food industry will be induced to develop new radiation resistant materials. Since packages for long-term storage of sterilized foods must be impermeable to oxygen, food board manufacturers may feel a competitive squeeze unless they develop new impermeable, easily sealed materials. In plastic films, certain of the polymers are adversely affected by radiation. Thus, the new laminated films may find a huge new market. When radiation sterilization becomes common, the tinplate can will be faced with long-run competition by less costly and less durable materials since irradiation will eliminate much of the need for resistance to heat and internal pressure.

Initially, we need not expect any great diminution in *refrigerated storage* requirements. Fresh foods already require refrigeration, and since pasteurized foods will partially displace fresh produce, no radical change should take place. Refrigerated storage space may even increase for a time because of the longer allowable holding period. Needs for refrigerated cabinets at the retail level will increase because of the wider variety of product lines that will accompany irradiated prepackaged fresh foods. As irradiated sterilized foods requiring no refrigeration become common, the growth in refrigerated storage space should decelerate to some extent.

IMPACT ON THE ELECTRONICS INDUSTRY

If electron sources are used for irradiating foods other than meats, over 300 large electron accelerators may be required by 1980. Disregarding investment requirements for physical plant, accessory equipment, and repair components, this could mean an annual market of $15 million to the *electronics industry*. This estimate is based on a 5 month, two-shift operating season with investment phased over a 10-year period. If gamma sources were used for irradiating meats with pasteurization dosages, an additional investment of $5 million annually would go into gamma sources. Further outlays would be necessary in order to replenish and maintain the original gamma sources.

SUMMARY

To summarize, food irradiation will have major impacts on several key industries. It will introduce a new flexibility into processing, transport, storage, and marketing of foods. In the food processing industry, frozen food processors may benefit most from its early impact, bu canners are apt to benefit to a greater extent in the long run. Fresh produce packers will experience a reduced share of the total food market. The perfected process will introduce whole new lines of products that will require added facilities for wholesaling, storage, and retailing. Consumers will be offered a greater selection of foods with more uniform quality including precooked meats and prepared foods.

The need for particle accelerators and accessory equipment will stimulate the market for electronic equipment and components. Initially, more refrigerated commercial storage equipment may be needed. Increased prepackaging of produce and meats should create an increased demand for more and better packaging.

These economic developments cannot be expected to take place until the irradiation process has been thoroughly tested and the economics of production are better understood. We believe that irradiated food will not enter civilian markets before the mid- to late 1960's.

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Qualities of Beef as Affected by Cooking at Very Low Temperatures for Long Periods of Time[a]

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(Manuscript received May 29, 1959)

ALTHOUGH THE METHOD and length of time of cooking have been recognized for some time as factors influencing the tenderness and juiciness of meat, definite information as to whether changes occur in the connective tissue only or in the muscle fibers as well is meager.

Early work *(1, 4, 5, 11, 19)* indicated that meat is more tender and juicy when cooked at low temperatures, and that these qualities are influenced by the internal temperature to which the meat is cooked. A number of workers *(3, 8, 10, 13, 14, 17)* have reported an increase in shrinkage and total cooking losses or a decrease in volume of press fluid with increases in internal temperatures.

Time of cooking rather than the cooking temperature has been suggested by Lowe *(12)* and Cover *(6, 7)* as a determining factor affecting tenderness. Cover *(7)* observed that roasts were always tender when the rate of heat penetration was slow enough so that they required 30 hours or more to lose their pink color.

The general belief has been that heat hardens muscle fibers, but with the less tender cuts, temperatures above 65° C. (149° F.) or extended heating to a well-done temperature of 80° C. (176° F.) or higher are required to soften the connective tissue *(21)*.

Recently more attention has been directed to the muscle fibers themselves. Wang *et al. (24)* studied the relationship between muscle fiber extensibility and tenderness of raw and cooked beef. Smith *(18)* observed the effect of various temperatures of heating on the breaking strength of the individual muscle fibers. There is lack of information as to when coagulation of the muscle fiber proteins occurs, but it is generally assumed that coagulation takes place between 57° C. (135° F.) and 75° C. (167° F.). There is probably no specific coagulation temperature since muscle fiber proteins are known to consist of several different proteins, each with a different coagulation temperature *(21)*.

This study was undertaken to determine the effect on less tender meat of cooking at very low oven temperatures for long periods of time.

PROCEDURE

Six pairs of U. S. Standard grade beef rounds were purchased from a commercial packing plant. Five muscles, as identified by Tucker *et al. (23)*, were used: the *adductor, biceps femoris, gracilis, semimembranosus,* and *semitendinosus.* Individual muscles were dissected from the round, wrapped in heavy duty aluminum foil, frozen and stored at approximately −30° C. (−22° F.). The meat was held in the original wrapping in a refrigerator at about 2° C. (34.6° F.) for 18 to 24 hours just prior to cooking.

Samples for chemical analyses and for tensile strength measurements were removed. Both before and after cooking the meat was weighed; the length, width, and thickness of each muscle were measured in centimeters; and a tracing was made of the surface of each muscle. Each muscle was wrapped in heavy duty aluminum foil, and cooked on an aluminum tray. One of each pair of muscles was cooked at 63° C. (145° F.) for 30 hours and the other at 68° C. (155° F.) for 18 hours. A record, at 4-minute intervals, of the oven temperature and the internal temperature of the meat at 3 different points was made possible by the use of a multipoint temperature recorder.

At the end of the cooking period samples were removed for chemical analyses and tensile strength measurements from the same general area as the raw samples had been taken. Samples for shear and press fluid determinations were removed. The remainder was sliced approximately one-eighth inch thick using a hand operated slicing machine. Some slices were used immediately for taste panel evaluation and the remainder were frozen and stored for later study.

The percentage of cooking losses was calculated. Moisture, fat and total protein content of the meat were determined by the methods of the AOAC *(2)*. Total nitrogen of the drippings, which had been strained to remove large particles of coagulated material, and of the press fluids were determined by the micro-Kjeldahl method.

Tensile strength measurements were made on individual muscle fibers using the apparatus essentially as developed by Smith *(18)*. Shear values were determined by use of the Warner-Bratzler shear on samples one-inch in diameter cut parallel to the fibers of the meat. Six or more readings were made on each sample. Press fluid determinations were made in the manner described by Harrison *et al. (9)*.

The taste panel used a five-point scale for rating the meat on appearance, tenderness, texture, juiciness, and flavor.

The data were treated statistically whenever it was considered feasible.

RESULTS AND DISCUSSION

The percentage of cooking losses was consistently less for meat cooked at 63° C. (Table 1) and averaged 23.5% as compared with 27.9% for that cooked at 68° C. Differences in losses due to cooking temperatures and to different muscles were highly significant at the 1% level. Variation in cooking losses of the muscles due to differences in the carcasses was significant at the 5% level.

The length, width, and thickness of each muscle, as

[a] Journal paper 1434, Departments of Foods and Nutrition and of Biochemistry, Purdue Agricultural Experiment Station, Lafayette, Indiana. A portion of the data were taken from a thesis submitted by Robert L. Hostetler in partial fulfillment of the requirements for the degree of Master of Science in home economics.

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TABLE 1

Average weight and percentage of cooking losses of paired muscles from six beef rounds

Muscle	Treatment		Raw weight	Cooking losses
	temp.	hr.		
	°C.		lb.	%
Adductor	63	30	1.37	26.58
	68	18	1.15	32.93
Biceps femoris	63	30	5.01	22.26
	68	18	4.44	24.70
Gracilis	63	30	3.04	21.23
	68	18	2.95	27.10
Semimembranosus	63	30	5.89	24.12
	68	18	5.96	26.69
Semitendinosus	63	30	3.48	22.32
	68	18	3.76	25.20

measured before and after cooking, indicated that there was a great deal of variation among and within the various muscles in the percentage of change which took place in each dimension during cooking. Although a few of the muscles did not change in any dimension, 92% decreased in length during cooking and 6% increased. Eighty-three per cent decreased in width and 14% increased. A much smaller percentage, only 67%, decreased in thickness whereas 29% increased. Although the change in shape of a cut of meat is of interest to the person serving it, the significance of the findings here reported is not clear.

The moisture content of all raw muscles averaged 72.9% and varied from an average of 70.0% for the *biceps femoris* to 74.5% for the *adductor* (Table 2). The average for the meat cooked at 63° C. was 67.6% and for that cooked at 68° C., 65.5%. The fat content of the muscles varied from 2.05% for the *adductor* to 5.28% for the *biceps femoris* and averaged 3.53%. The high fat content of the *biceps femoris* to be cooked at 63° C. is no doubt due in part at least to sampling error (Table 2). The average fat content for all meat cooked was 3.33% and averaged 3.71% for the meat cooked at 63° C. and 2.94% for that cooked at 68° C. The protein content varied little from muscle to muscle and averaged 22.8% for the raw and 29.5% for the cooked. The protein average for meat cooked at 63° C. was 28.3% and that cooked at 68° C. was 30.6%. The higher moisture content in the meat cooked at 63° C. was reflected in the lower percentage of protein.

The drippings from the meat cooked at 63° C. were higher in nitrogen than those from meat cooked at 68° C., probably because more of the protein lost in the drippings was coagulated at the higher temperature and hence removed when the drippings were strained. There was a slightly greater amount of nitrogen in the press fluid from meat cooked at 63° C. as compared with that cooked at 68° C., and the difference was consistent enough to be significant. Child and Fogarty *(3)* also found more total nitrogen in the press fluids of meat cooked to lower temperatures and concluded that an inverse relationship existed between the nitrogen content of the press fluids and the interior temperature.

Differences in pH of the drippings and of the press fluids due to methods of cooking were slight but for both the pH was lower for meat cooked at 63° C. than at 68° C.

Three methods of evaluating tenderness were used, namely the tensile strength of muscle fibers, the Warner-Bratzler shear and the taste panel.

The major problem in the tensile strength determinations was in isolating enough fibers. Unless 10 or more fibers were broken for a given test it was considered incomplete. Successful tests were run on approximately 65% of the muscles from the left side of the carcass but only 44% from the right side.

The average tensile strength, in grams, of the fibers from the raw muscles, considering both the right and left sides, was: *adductor* 0.74; *biceps femoris* 0.69; *gracilis* 0.46; *semimembranosus* 0.69 and *semitendinosus* 0.74. Although fibers from four of the muscles showed little difference in tensile strength those from the gracilis were somewhat lower than the others. Wang *et al. (24)* found no marked difference in the extensibility of fibers from the semitendinosus and the longissimus dorsi muscle in the fresh raw state, nor did Smith *(18)* note great difference in the breaking strength of single fibers from different muscles. Considering all determinations, fibers from the mus-

TABLE 2

Analytical data for paired muscles of U. S. standard beef rounds cooked by two methods [1]

Muscle	Treatment		Moisture		Fat		Protein		Nitrogen		pH	
	temp.	hr.	Raw	Cooked	Raw	Cooked	Raw	Cooked	Drippings [2]	Press fluids	Drippings [2]	Press fluids
	°C.		%	%	%	%	%	%	%	%		
Adductor	63	30	74.2	67.3	1.65	3.42	23.6	29.3	.88	.84	5.94	5.99
	68	18	74.7	65.6	2.44	1.96	22.3	23.1	.69	.71	5.97	6.05
Biceps femoris	63	30	69.4	68.2	8.24	4.17	21.3	27.8	1.04	.98	5.85	5.85
	68	18	70.5	64.1	2.32	4.48	21.0	30.7	.76	.76	5.94	5.95
Gracilis	63	30	73.4	68.2	3.63	3.48	24.1	28.7	.90	.87	5.94	6.00
	68	18	74.1	66.1	3.45	2.39	21.5	29.5	.81	.79	6.07	6.03
Semimembranosus	63	30	72.4	65.5	3.91	4.78	24.0	28.1	1.04	1.03	5.85	5.84
	68	18	72.6	65.1	4.35	3.08	23.8	31.3	.90	.94	5.98	5.98
Semitendinosus	63	30	73.4	69.1	2.81	2.74	23.5	27.7	.94	.98	5.80	5.79
	68	18	73.8	66.4	2.49	2.76	22.2	29.3	.76	.82	6.00	5.90

[1] Figures represent averages for 3 pair of rounds, only.
[2] Coagulated proteins had been removed by filtering.

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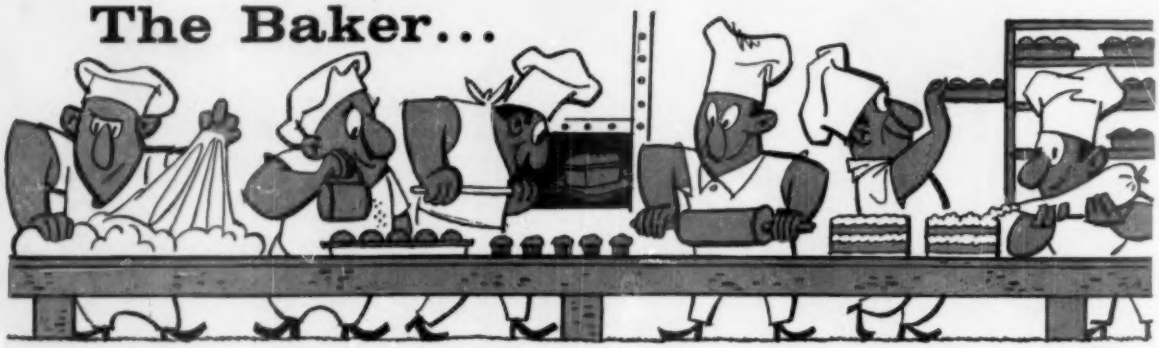

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cles cooked at 63° C. had a lower tensile strength than those of the raw meat, except for the gracilis. The difference was significant at the 1% level. Fibers from the raw meat and that cooked at 68° C. were not statistically different, but in general, the cooked fibers had a lower breaking strength. For the most part, tensile strength measurements of fibers from meat cooked at 63° C. were lower than those from meat cooked at 68° C.

Although a study of the individual muscle fibers seems to offer promise as a means of evaluating tenderness, it is tedious and time consuming. Furthermore it seems that a refinement of the method used in this study will be necessary before significant and reliable results will be obtained. Results obtained by the Warner-Bratzler shear and the taste panel scores are much more clear-cut and consistent. Both of these tests indicated that the meat cooked at 63° C. was more tender than paired cuts cooked at 68° C. (Table 3). Taste panel scores averaged 4.00 for the meat cooked at 63° C. as compared to 3.29 for that cooked at 68° C. (maximum score 5.0), and the shear values averaged 12.94 and 17.76 pounds, respectively. These differences were significant at the 1% level for both the taste panel scores and for shear values.

Although meat cooked at 63° C. was apparently more tender than that cooked at 68° C. as evaluated by breaking strength of individual muscle fibers, by the Warner-Brazler shear and by the taste panel scores, no significant correlation was found between the breaking strength measurements and either of the other two tests. This too would seem to bear out the conclusion that more work needs to be done on the tensile strength measurements of individual fibers before the results can be considered meaningful.

Ramsbottom *et al. (15, 16)* and Strandine, Koonz, and Ramsbottom *(20)* have demonstrated that variability in tenderness exists from muscle to muscle. In this study, differences in tenderness scores and in shear values due to muscles were highly significant.

The *adductor* and the *gracilis* were significantly (at 1%) more tender, as measured by shear values than the other three. However, the differences between the first two mentioned or among the other three did not approach significance. Significant differences in tenderness scores and shear values due to variations in the carcasses were significant at the 1% level. These results correspond with findings of Harrison *et al. (9)* who reported differences in tenderness due to different animals.

Average taste panel scores for juiciness and the press fluid yields for muscles cooked at 63° C. were consistently greater than for the corresponding muscles cooked at 68° C. (Table 3). Differences in both factors were highly significant. These data agree with those of Halliday *et al. (8)* who reported a higher yield of juice with a lower cooking temperature. A positive correlation coefficient for juiciness scores and press fluid yields indicated that these measurements tend to agree in the evaluation of juiciness of the muscles. Tanner, Clark, and Hankins *(22)* also reported that the coefficients of correlation between committee scores and expressible juice content of beef samples were of sufficient magnitude to be encouraging.

Differences due to muscle were highly significant for juiciness scores and significant at the 5% level for press fluid yields. For both methods of cooking, the *gracilis* and *semimembranosus* were rated the most juicy of the muscles used.

Variation in juiciness among carcasses was reflected more in the press fluid yields than in the panel scores. Differences due to carcasses were highly significant for press fluid yields and approached significance for juiciness scores.

No significant difference was found in the flavor scores for the two methods of cooking (Table 3).

Meat cooked at the lower temperature for the longer period of time was scored higher in appearance and texture than the corresponding muscles cooked at the higher temperature. Meat cooked at 68° C. looked drier and more nearly well-done than meat cooked at 63° C., the latter appeared more moist and somewhat rare, and was preferred by the panel. The differences in the scores for appearance were significant for the method of cooking, highly significant for the different carcasses and approached significance for the different muscles. Highly significant differences were found in

TABLE 3

Average of taste panel scores, shear values, and press fluid yields of five muscles from six beef rounds

Muscle	Treatment		Appearance[1]	Tenderness		Texture[1]	Juiciness		Flavor[1]
	temp.	hr.		Panel[1]	Shear[2]		Panel[1]	Press fluids[3]	
	°C.								
Adductor	63	30	4.09	4.13	10.58	4.06	3.41	7.10	4.02
	68	18	3.79	3.38	14.47	3.61	2.79	5.60	3.99
Biceps femoris	63	30	4.06	3.83	12.35	3.86	3.60	6.67	3.92
	68	18	3.72	2.72	18.77	3.65	2.87	5.95	3.86
Gracilis	63	30	4.05	4.19	10.42	4.01	3.91	7.42	4.07
	68	18	4.04	3.75	15.27	3.98	3.43	6.43	3.96
Semimembranosus	63	30	4.08	3.96	13.76	3.92	3.63	7.23	3.94
	68	18	3.86	3.37	15.81	3.80	3.26	7.06	3.93
Semitendinosus	63	30	3.72	3.91	15.01	4.03	3.40	7.15	4.05
	68	18	3.84	3.23	18.01	3.91	2.80	6.31	3.96

[1] Maximum score 5.0.
[2] Expressed as lbs. of force required to shear a sample one inch in diameter.
[3] Expressed as ml./25 g.

texture scores due to method of cooking and significant differences due to carcass variations.

In view of the small differences between the cooking temperatures of 63° and 68° C., it seems remarkable that highly significant differences were observed in quality factors for meat cooked by the 2 methods. The length of time the meat was held at an internal temperature of 57° to 60° C. appeared to be a decisive factor and closely related to an increase in tenderness. This was shown by a highly significant negative correlation (−.73) for the length of time the meat was within this temperature range and for shear values (Figure 1). It would seem that at this temperature changes take place in both the muscle fibers and connective tissue which result in more tender meat.

The fact that meat in this study was cooked at very low temperatures for long periods of time may account for the differences between these results and those obtained by other workers who reported a toughening effect of heat on muscle fibers. Other workers used considerably higher temperatures and/or short cooking periods. Wang *et al. (24)* broiled steaks at 202° C. (400° F.), Ramsbottom and Strandine *(16)* cooked meat in lard at 121° C. (250° F.) for 6 to 15 minutes, Satorius and Child *(17)* roasted muscles at 150° C. (303° F.), and Smith *(18)* cooked small pieces of meat in water at 50° C. (122° F.), 60° C. (140° F.), 70° C. (158° F.), and 80° C. (176° F.) for 10 minutes. Under the cooking conditions used in this experiment, it was a matter of hours before the final internal temperature of 60° C. (140° F.) was reached by the meat cooked at 63° C. (145° F.) and of 65° C. (149° F.) by the meat cooked at 68° C. (155° F.).

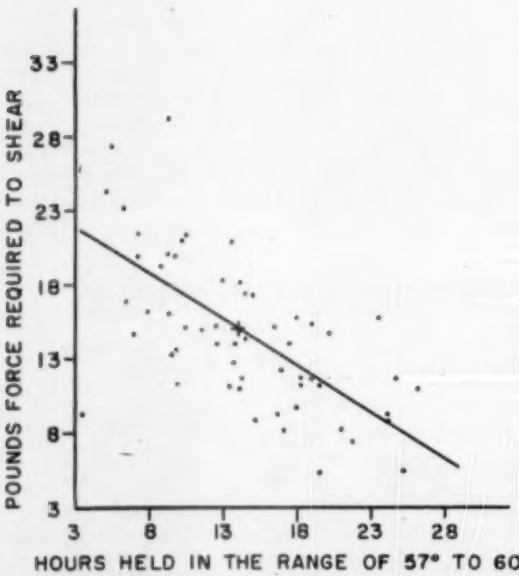

Figure 1. Scatter diagram of pounds force required to shear one inch diameter cores with the Warner-Bratzler shear versus the length of time the internal temperature of the meat was within the temperature range of 57° to 60° C. showing the regression line with "r" equal to −0.73 (Y = 23.66 − .6209X).

Meat cooked at 63° C. for 30 hours required an average of 12 hours to reach an internal temperature of 57° C. and was held in the temperature range of 57° C. to 60° C. for from 13 to 24 hours or an average of 18 hours. On the other hand, meat cooked at 68° C. took from 5 to 14 hours, an average of 8 hours, to reach 57° C. and was held at this temperature or above for an average of 10 hours. However, during this time the temperature continued to rise and reached a final internal temperature of approximately 65° C.

It is quite evident that the time-temperature combinations used in this study had an effect on the tenderness of the meat, probably causing both physical and chemical changes in the connective tissue and in the muscle fibers themselves. The findings suggest the possibility for further study to find conditions that would produce the desired softening in the connective tissue with the least change in the muscle fibers.

SUMMARY

Five muscles from six pairs of U. S. Standard grade beef rounds were cooked, one of each pair at 63° C. (145° F.) for 30 hours and the other at 68° C. (155° F.) for 18 hours and evaluated by objective and organoleptic methods.

Meat cooked at 63° C. as compared with that cooked at 68° C. had a lower percentage of cooking losses, a higher per cent moisture content and a lower protein. The nitrogen content of the press fluid was higher. The meat was significantly more tender as evaluated by the Warner-Bratzler shear and by a taste panel and tended to be more tender as evaluated by tensile strength measurements of individual fibers. The press fluid yields and scores for juiciness, texture, and appearance were greater for meat cooked at 63° C. but flavor scores were not significantly different.

Significant differences were found due to muscle for: cooking losses, shear values and yields of press fluid; taste panel scores for tenderness and juiciness, and to animal for cooking losses, shear values, tenderness scores and press fluid yield. Differences due to animal approached significance for juiciness scores.

Acknowledgment

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Uniformity of Color Measure in Green Beans[a]

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COLOR IS an organoleptic quality of foods related to consumer acceptance. It is often a factor in U. S. Department of Agriculture food grades. As a result, instruments have been used in attempts to measure color objectively. The applications, however, have been to measurements of base characteristic color *(1, 3, 4)*, and to unilateral deviations from an arbitrary standard color. Many aspects of the subject, "Color in Foods," are reviewed and discussed in the Symposium *(2)* sponsored by the Quartermaster Food and Container Institute for the Armed Forces.

No objective measure of degree of uniformity of color is presently available. Many U.S.D.A. food grades specify a "uniformity of color" factor, as well as a "typical" or base color for the product. This reflects a consumer interest in color uniformity which in turn is reflected in the food processor's concern about color quality.

During an objective evaluation of green beans for processing *(6)*, the authors noted the rapidity with which individual color measurements could be made with a photoelectric filter photometer such as a Hunter Color and Color Difference meter *(1)*. This ex-

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perience suggested the practicability of a basic statistical approach to a uniformity measure. If enough individual color measurements are made, the bilateral distribution of these values from the mean color value should be a measure of degree of uniformity. *One* value expressing the extent of this distribution is the mean square (variance, s^2) calculated from a number of individual color determinations. The square root of this is the standard deviation *(s)*; 68% of the values in the normal sample distribution are in the interval $m \pm s$. The magnitude of s is a quantitative measure of the extent of color variability (disuniformity).

Figure 1 illustrates this concept graphically. For the purpose intended, the mean square can be used as an intrinsic "property" of the population. In order to avoid confusion in terminology, this "property" can be called *disuniformity* with a numerical value of D (i.e., $D = s^2$). One can now use D as a single characteristic value, in the same way that average color values can be used in analysis of variance. The magnitude of D is inversely related to the degree of uniformity of the sample.

MATERIALS AND METHODS

Two commercial strains of Blue Lake beans were used. One of these (No. 1), Associated's Stringless 228, was selected as a standard of uniformity. For comparison Germain's Germain 21 (No. 2) was used. The Germain strain was suspected of being relatively nonuniform in color. A synthetic mix (No. 3) also was grown. The seed mix was composed of ¾ Germain's 21 and ¼ Stringless 228. A randomized block field plot design was employed. Growing conditions were similar to those described by Moore and Allmendinger *(5)*.

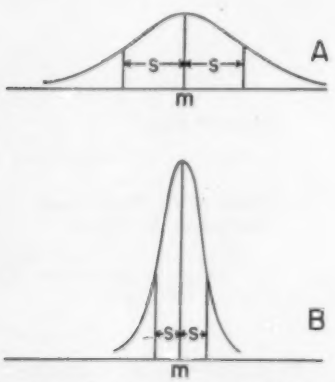

Figure 1. Hypothetical normal distribution curves. Different magnitudes of standard deviation, *s* differentiate population A from population B on the basis of uniformity with respect to the mean (m).

Hand-picked beans were brought to the Food Processing Laboratory, Western Washington Experiment Station, Puyallup, where they were stored in sacks in a cool shed overnight. The beans were snipped and sized-graded mechanically. Small sizes (Nos. 1, 2, 3) were frozen whole, but the Nos. 4 and 5 were cut in 1½ in. lengths in a Herschel cutter for canning. All beans were steam-blanched the minimum time for peroxidase inactivation. The whole beans were packaged in 1-pt. polyethylene bags and frozen in an air blast. The cut beans were canned in dilute brine in No. 2 cans. One package and 3 cans were processed per treatment per field replication for color evaluations.

Frozen samples were thawed on a ¼ in. screen under a spray of cold tap water for 5 minutes, then allowed to drain 5 minutes. Canned samples were drained through an 8-mesh screen for 2 minutes as described for the drained weight procedure of U. S. Standards for Grades for Canned Green Beans *(7)*.

Uniformity of color samples. The Hunter Color and Color Difference meter was equipped for small area (S) and large area (L) illumination. The S setting, which produced a two-spot image, was used to obtain color readings on single bean units, using the plastic base block with a half-inch opening. Individual bean units (1 in.–1½ in.) were split at the suture line and placed with the outside surface facing down on a watch glass. The glass was arranged over the half-inch opening so that the 2 spots of illumination struck the 2 sides of the opened bean, i.e., one spot on each side. Fifty color measurements were made on each of 50 randomly selected units for calculation of D values of a sample (from one package of frozen-thawed, or from one can). The D values were also calculated for 25 and for 10 randomly selected color determinations out of the 50. Analysis of variance for these D values showed errors of a magnitude to make them unacceptable compared with D values calculated from 50 separate determinations. Color value variations along the length of individual beans and on the 2 sides were found to be small compared with bean to bean variations.

Base characteristic color. Mean color values obtained from the uniformity samples were used as one measure of characteristic color. Another measure was obtained from a duplicate sample of approximately 50 units ground through a Universal food chopper (with a 16-spoke wheel). The ground sample was spread about ⅝ in. deep in a Petri dish and the reflectance values measured with meter lenses in the L position, using a base plate with 2¼ in. opening.

RESULTS AND DISCUSSION

Results are summarized in Tables 1–5.

The R_d color values in Table 1 show significant differences in uniformity between seed strains in canned beans. In line with the original basis for selection of seed strains, the smallest D_R values (most uniform color) are for beans from No. 1 (Stringless 228). Beans from the strain No. 2 (Germain 21) had the least uniform R_d values as indicated by the largest D values. The relative magnitude of the D_b values and the 5% level significance owing to strains indicate

TABLE 1

Average disuniformity (D) of Hunter meter readings for 50 beans from each of three canned samples

Picking times	Seed strain						
	No. 1		No. 2		No. 3		Total
	(R_d)	(b)	(R_d)	(b)	(R_d)	(b)	(b)
8/13	2.43	1.77	4.44	1.70	3.67	1.56	5.03
8/17	3.52	2.22	4.32	2.36	3.44	1.83	6.41
8/22	2.19	2.80	5.38	2.79	4.05	2.20	7.80
8/29	3.55	2.32	4.21	3.33	3.41	2.42	8.07
Total	13.16	9.10	18.36	10.17	14.58	8.01	

Analysis of Variance for D

Factor	d.f.	M.S.		
		R_d	$-a$	b
Strains	2	21.71**	0.22	3.49*
Picking times	3	4.75	0.05	7.85**
S × P	6	1.85	0.02	0.89
Replications	3	9.27*	0.03	2.98*
Error	33	1.82	0.03	0.73
Sampling error	96	1.38	0.02	0.86

* 5% level significance.
** 1% level significance.

minor uniformity differences in the *b* color coordinate. No significant differences exist between the D_{-a} values which average 0.52 for the 3 strains and 4 picking times.

A regular and significant decrease in uniformity of *b* values in canned beans occurs as the picking time becomes progressively later. Since R_d values do not show a corresponding change, results indicate an increasing spread in the yellow-green factor at later picking times without a change in uniformity of lightness and darkness of individual bean units. It is evident from Table 2 that the D_b values of frozen beans follow a similar trend.

Frozen beans do not show the significant seed strain differences in uniformity of color as do canned beans,

TABLE 2

Average disuniformity (D) of Hunter meter readings for 50 beans from single packages of frozen beans

Color factor	Picking times			
	8/13	8/17	8/22	8/29
b	2.90	4.15	5.03	3.81

Analysis of Variance for D

Factor	d.f.	M.S.		
		R_d	$-a$	*b*
Strains	2	4.41	0.74	3.16
Picking times	3	5.22	0.57	9.34**
S × P	6	2.13	0.25	2.11**
Replications	3	5.54	0.11	2.44
Error	33	1.64	0.34	1.60

* 5% level significance.
** 1% level significance.

due to different seed strains. The over-all average (3 strains x 4 picking times) of D_R is 3.45 for frozen beans. The average D_{-a} is 1.59, 3 times the disuniformity property of the *a* color coordinate of canned beans. On the other hand, the magnitude of R_d disuniformity is much less for frozen than for canned samples. Heat processing thus increases variability in light to dark in the beans; freezing minimizes this variability and increases variability in greenness.

In comparing frozen with canned beans, another difference besides a processing one is involved, i.e., a size difference. The frozen beans represent those graded out small (Nos. 1, 2, 3). Previous work *(6)* showed a change in base color with size. Larger beans had higher R_d values (lighter green) than the smaller.

Tables 3 and 4 show that the base color differences (R_d) due to seed strains are greater for canned beans than for frozen. Furthermore, these differences are larger than those resulting from processing treatment alone, as found in the earlier work *(6)*.

There is a significant correlation between R_d base color expressed as the mean from uniformity measurements and R_d values determined directly on ground bean samples ($r = 0.476$ for canned, 0.629 for frozen beans). The base color becomes progressively lighter as picking time advances. However, picking time differences are not significant in ground, canned samples, likely because of the incorporation of seeds in these larger-sized beans.

TABLE 3

Average base color values (Hunter meter readings) of R_d of composite ground samples (Gr) compared with means (M) for surface readings from 50 individual bean units, using triplicate canned samples

Picking times	Seed strain							
	No. 1		No. 2		No. 3		Total	
	(Gr)	(M)	(Gr)	(M)	(Gr)	(M)	(Gr)	(M)
8/13	18.44	11.82	22.55	15.05	20.11	13.50	61.11	40.38
8/17	19.08	12.05	20.66	13.86	19.80	13.26	59.53	39.19
8/22	17.95	11.87	20.10	13.21	19.01	12.50	57.06	37.53
8/29	18.20	11.22	18.57	11.63	18.44	12.01	55.21	34.87
Total	73.67	46.92	81.90	53.76	77.36	51.28	232.94	151.97

Analysis of Variance

Factor	d.f.	M.S.	
		(Gr)	(M)
Strains	2	50.91**	35.98**
Picking times	3	2.15	22.79**
S × P	6	7.45	4.42**
Replications	3	27.20**	1.67
Error	33	4.11	0.58
Sampling error	96	3.32	0.50

* 5% level significance.
** 1% level significance.

Analysis of the data for $-a$ and *b* values does not show a significant correlation between ground samples and the mean of individual unit measurements. Correlation coefficients for canned samples are 0.0024 for *a* values and 0.172 for *b* values; for frozen beans these coefficients are 0.081 and 0.266, respectively. However, significant differences owing to both strains and picking times are evident in the means for canned beans (Table 5). This is in line with previous findings which indicated a heat processing effect on the yellow-green factors, $-a$ and *b* *(6)*.

Analysis of the data on $-a$ and *b* values for frozen beans does not show significant differences with respect to either strains or picking times. Over-all averages of mean base color values for the 3 strains and 4 picking times are 8.89 for $-a$ and 16.36 for *b*. The relatively high negative value for $-a$ along with the relatively low R_d values for base color of frozen beans

TABLE 4

Average base color values (Hunter meter readings) of R_d of composite ground samples compared with means for surface readings from 50 individual units, using single package samples of frozen-thawed beans

Picking times	Seed strain							
	No. 1		No. 2		No. 3		Total	
	(Gr)	(M)	(Gr)	(M)	(Gr)	(M)	(Gr)	(M)
8/13	13.80	9.71	17.30	11.53	15.10	10.59	46.20	31.83
8/17	15.05	9.72	16.37	10.86	15.22	9.80	46.65	30.38
8/22	12.32	8.60	13.92	9.00	14.30	9.40	40.55	26.99
8/29	13.35	9.30	13.02	8.47	13.12	8.75	39.50	26.53
Total	54.52	37.33	60.62	39.86	57.75	38.54	172.90	115.74

Analysis of Variance

Factor	d.f.	M.S.	
		(Gr)	(M)
Strains	2	9.31*	1.61**
Picking times	3	18.49**	8.92**
S × P	6	3.26	1.56**
Replications	3	2.04	0.41
Error	33	2.01	0.28

* 5% level significance.
** 1% level significance.

is a quantitative measure of the deeper or darker green of frozen as compared with the canned beans.

CONCLUSIONS

Standard deviation can be used equally as well as mean squared deviation, but the former involves the extra calculation for taking the square root. Standard deviation however, has applied meaning when viewed in the light of the U.S.D.A. color grade for green beans *(7)* which specifies " . . . 5, 10, and 15%, by count, which vary markedly from this color . . . " (i.e., the "typical" color), respectively for the 3 grades.

Assuming that a standard bean variety results in a Grade A processed product with respect to uniformity of color, the above percentage limits can be used to calculate D value limits for the three grades. Specifically, for strain No. 1, quantitative grade limits can

TABLE 5

Means of Hunter meter readings for 50 individual bean surface measurements, using canned samples in triplicate

Picking times	Seed strain							
	No. 1		No. 2		No. 3		Total	
	(−a)	*(b)*	*(−a)*	*(b)*	*(−a)*	*(b)*	*(−a)*	*(b)*
8/13	0.51	17.09	0.95	17.47	0.95	17.66	2.41	52.22
8/17	0.46	17.71	0.90	17.58	0.69	17.82	2.05	53.01
8/22	0.43	17.00	0.74	17.58	0.62	17.21	1.80	51.79
8/29	0.34	16.42	0.34	16.13	0.47	16.57	1.16	49.13
Total	1.75	68.11	2.94	68.77	2.73	69.27		

Analysis of Variance

Factor	d.f.	M.S.	
		−a	*b*
Strains	2	1.22**	1.00**
Picking times	3	1.11**	11.36**
S × P	6	0.17	0.62
Replications	3	0.09	0.45
Error	33	0.10	0.29
Sampling error	96	0.11	0.92

* 5% level significance.
** 1% level significance.

be calculated as follows, using confidence limits of 5%, 10%, and 15% obtained from normal distribution tables:

Average D (R_d) from Table 1 = 3.29

$$s = \sqrt{D} = 1.8$$

And 95% of the R_d values are included in the range $\pm 2s$, i.e., $4s$, or 7.2 R_d units.

For the 10% confidence interval this range will be larger, and is calculated from the relationship

$$1.64\, s_{10} = 2s$$
$$s_{10} = 2.2 \text{ } R_d \text{ units}$$

Assuming $\pm 2s_{10}$ establishes R_d limits for Grade B,

$$D_B = s_{10}^2 = 4.84$$

In the same way for the 15% confidence interval,

$$1.44\, s_{15} = 2s$$
$$s_{15} = 2.5$$

And $\pm 2s_{15}$ establishes Grade C limits

Then $D_C = s_{15}^2 = 6.25$

On this basis, grade limits for uniformity of color in canned green beans can be set up from experimentally determined D values as follows:

Grade A: $D \leq 3.4$
Grade B: $3.4 < D \leq 4.9$
Grade C: $4.9 < D \leq 6.4$

Another criterion for the grade is needed, though, i.e., a definition of acceptable "typical" color. For this purpose the range of a standard which includes 68% of the color values can be used. For example, the mean R_d value of strain No. 1 is 11.7 (Table 3) and this acceptable range is 11.7 ± 1.8, or from 9.9 to 13.5 R_d units.

Grade standards of color uniformity for canned beans as established for strain No. 1 can be used to determine grades for strains Nos. 2 and 3:

Strain No.	Mean R_d	Base color	D value (R_d)	Grade
No. 2	13.4	Acceptable	4.59	B
No. 3	12.8	Acceptable	3.65	B

The concept of this measure for uniformity can likely be applied to quality factors other than color, e.g., texture as measured by various texture meters, or sweetness as measured by soluble solids. In some cases, perhaps, coefficient of variation may prove useful, particularly if there is a large difference between sample means and the uniformity factor becomes masked as the mean changes.

SUMMARY

To meet a need for a quantitative uniformity measure in grading and quality evaluation, a statistical "property" of a sample population was defined for that purpose. The "property" was the average square of the deviation from the mean value for the quality factor under investigation. The measure was applied to color evaluation of processed Blue Lake beans for three seed strains and four picking times. Color was measured by the Hunter Color and Color Difference meter. Analysis of variance for the uniformity measure showed significant differences between strains and between picking times. Possible influences of bean size and processing treatments are discussed. Mean color values of uniformity samples are used to characterize the base, or over-all, color. Effects of seed strain, picking time, size grade and processing treatment on this base color are reported.

Limits for color variation in canned green beans, as specified by U. S. Department of Agriculture grade standards, are determined by simple statistical calculations based on objective color data obtained with an acceptable standard variety. An example of color uniformity grading by these limits is given.

Acknowledgments

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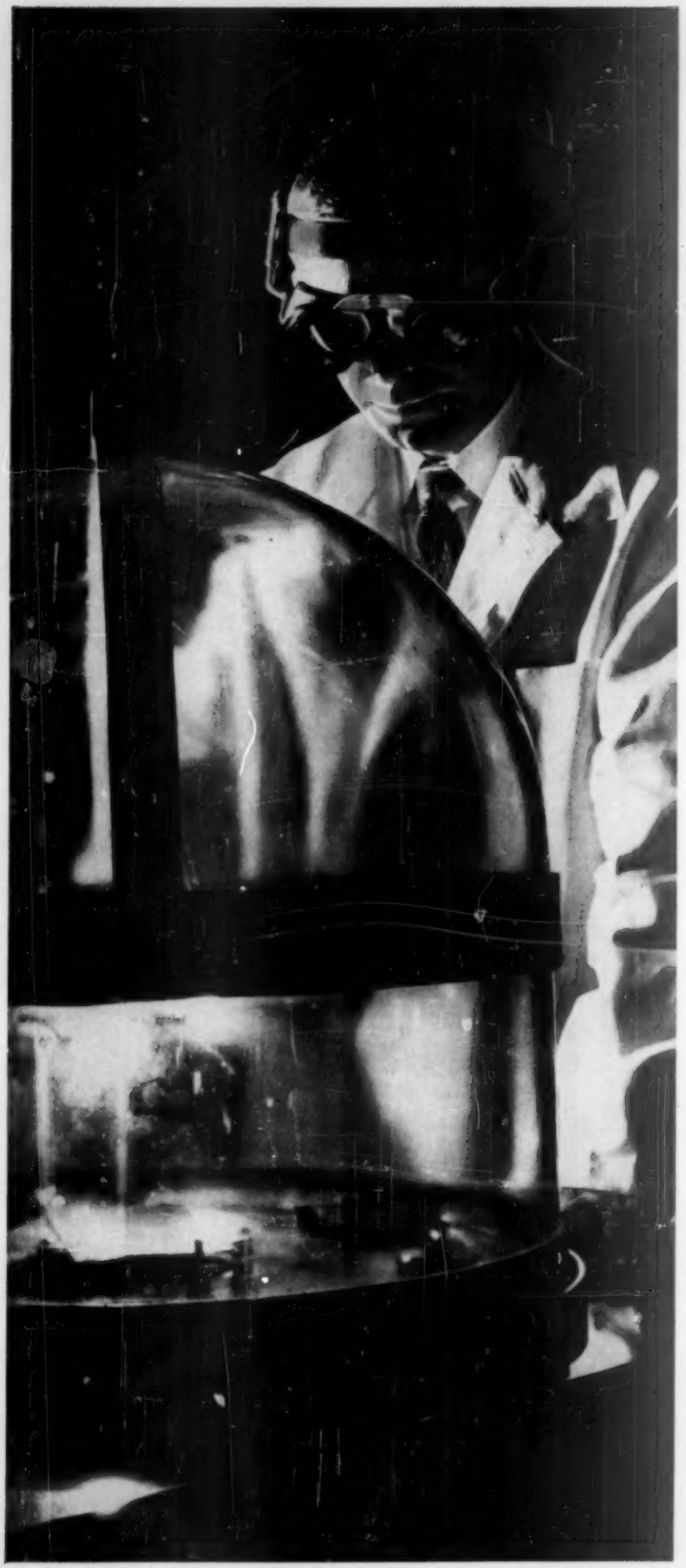

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sistance in making color determinations; Mr. Everett R. Wolford and Mr. John A. Sacklin, U. S. Fruit and Vegetable Products Laboratory, Puyallup, Washington, for preparation of processed bean samples; Dr. John F. Moore who supervised field production of the beans, Dr. Moore is now with the Campbell Soup Co., Department of Agricultural Research, Riverton, N. J.

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Moisture Transfer in Combinations of Dehydrated Foods[a, b]

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(Manuscript received May 26, 1959)

AN EARLIER paper *(3)* listed several practical uses for data which show the relationship between moisture and moisture-vapor pressure in dehydrated foods. It is the purpose of this paper to expand on one of these—that of computing the moisture transfer among two or more dehydrated foods within a package.

Dehydrated foods normally have good shelf life if the moisture content is maintained within narrow limits. However, stability is impaired in mixtures of dehydrated foods which differ in moisture-vapor pressure. In such combinations there is a transfer of water from items of higher moisture-vapor pressure to those of lower moisture-vapor pressure until pressure equilibrium is reached. In a review article, Makower *(2)* stated that it would be possible to predict the transfer of moisture from one ingredient to another from the knowledge of the vapor pressures of the individual ingredients. He did not, however, indicate how this could be done quantitatively. In a study of confectionery, Grover *(1)* did develop formulas for computing the equilibrium relative humidity of mixtures. The application of Grover's method, however, is limited to solutions of known chemical composition.

Important among the newer military feeding systems under development is the use of precooked dehydrated meals. The only field preparation required for these "quick-serve" meals is reconstitution with either hot or cold water. Components of these meals which are in themselves stable may have poor shelf life as a result of transfer of moisture to or from other components.

Figure 1 shows a six-man ration of precooked ground beef and potato hash which is part of a breakfast menu. It contains 400 g. of food and requires 37 oz. of water for reconstitution. It is packaged in a moisture-vapor proof, plastic- and foil-laminate contained in a paper-board carton. Among the ingredients are:

	Per cent moisture	Vapor pressure at room temp. as per cent relative humidity
	(approximate)	*(approximate)*
Ground beef	1–2	1–4
Potato dice	6–7	27
Minced onions	3	20
Beef soup and gravy base	3	34
Small amounts of spice and coloring	....	....

Thus, the individual moisture-vapor pressures, expressed as per cent relative humidity, may differ by as much as 30%. These differences in relative humidity are responsible for the migration of water from one ingredient to another.

[a] Presented at the 18th Annual Meeting of the Institute of Food Technologists, Chicago, Ill., May 26, 1958.

[b] This paper reports research undertaken by the Quartermaster Food and Container Institute for the Armed Forces and has been assigned No. 877 in a series of papers approved for publication

[c] Present address: University of California, Los Angeles.

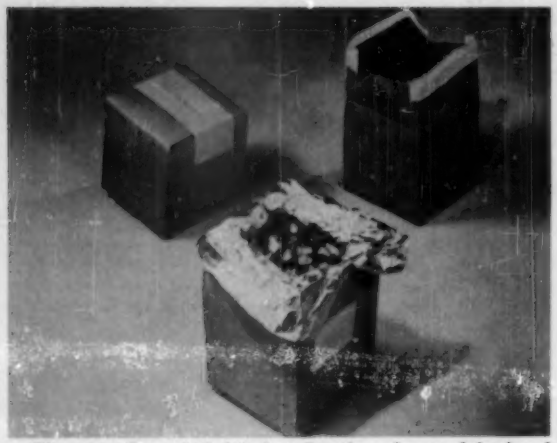

Figure 1. Precooked dehydrated ration of ground beef and potato hash.

The attention being given here to the relationship between moisture and moisture-vapor pressure is for the purpose of predicting the extent of moisture transfer among, and hence the packaging compatibility of, the components in combinations such as this.

MATERIALS AND METHODS

Prediction of equilibrium relative humidity and moisture transfer. With just two ingredients in a package, the direction of moisture transfer is obvious and the equilibrium point can be estimated with reasonable accuracy. However, neither the direction nor the extent of transfer is obvious when there are as many as 4 or 5 ingredients.

Figure 2 shows portions of two S-shaped curves which are typical of moisture sorption isotherms. In this and in all subsequent discussions, moisture contents are expressed as per cent of solids (i.e., on a dry basis). M_{A_1} is the initial moisture content of component A and R_A is the corresponding relative humidity. M_{B_1} and R_B are the initial moisture content and relative humidity of component B. If A and B were packaged together there would be a transfer of water from the one of higher to the one of lower relative humidity (from B to A) until equilibrium was reached—designated R. The new moisture contents would be M_{A_2} and M_{B_2}.

We are concerned with a relatively small range of moisture values in dehydrated foods—usually from 1 to 7%. Assuming straight-line functions between the initial and equilibrium relative humidities, the slopes of the lines equal the change in moisture content divided by the corresponding change in relative humidity.

$$\text{Slope of A} = S_A = \frac{M_{A_2} - M_{A_1}}{R - R_A} \qquad (1)$$

$$\text{Weight gain by A} = \frac{(M_{A_2} - M_{A_1})W_A}{100} = \frac{(R - R_A)S_A W_A}{100} \qquad (2)$$

in which W_A is the dry weight of A.

$$\text{Weight gain by A and B} = \frac{(R - R_A)S_A W_A}{100} + \frac{(R - R_B)S_B W_B}{100} = 0 \qquad (3)$$

The second term of equation 3 is negative inasmuch as R_B is larger than R. This term represents the weight of water lost by B to other components of the system and the net water gain, or water transfer, for the system is zero. Solving for R:

$$\text{Equilibrium relative humidity} = R = \frac{R_A S_A W_A + R_B S_B W_B}{S_A W_A + S_B W_B} \qquad (4)$$

The numerator and denominator of equation 4 will have as many terms as there are components in the system.

The W and initial R terms in equation 4 are either known or can be determined experimentally. The S terms are functions of R (equation 1), and their values can be estimated by first making a preliminary estimate of R. This is done by assuming, temporarily, that all of the slopes are equal. Equation 4 then provides an estimate of R which is used in equation 1 to evaluate the S terms. These values are then used in equation 4 to calculate a more exact value for R. As will be demonstrated later, a sizeable error in the preliminary estimate of R is largely compensated for by the appearance of each S term in both the numerator and denominator of equation 4. If desired, discrepancies between estimated and final values of R can be reduced by repeating the process of substituting in equations 1 and 4.

Thus, the equilibrium relative humidity (R) for the system can be computed from the dry weights of the components, the initial equilibrium relative humidities for each component taken from the appropriate isotherms, and the estimated slopes of the isotherms between the initial and final points. Having established the value for R, the final equilibrium moisture content of each component in any combination of foods can be determined by reference to the isotherms.

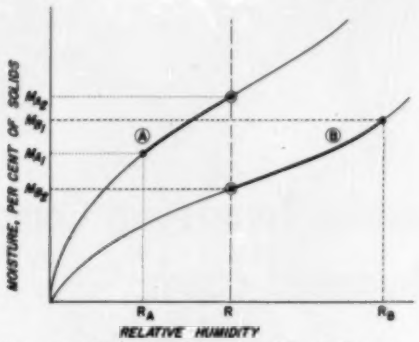

Figure 2. Typical moisture sorption isotherms.

Isotherms were determined for precooked dehydrated ration components by the desiccator equilibration method *(3)*. This required from 1 to 4 weeks, depending on the temperature. With equations 1 and 4, equilibrium relative humidities and final equilibrium moisture contents were computed for typical ration combinations of these ingredients.

Determination of moisture transfer. In order to test the validity of the predictions, the calculated values were compared with equilibrium moisture contents determined experimentally.

Figure 3 shows the method by which the extent of moisture transfer within a mixture was actually determined. Weighed portions of ration ingredients were placed into separate stainless-steel wire-screen baskets. The weights were in proportion to those of the ration formula. Several baskets were placed into a tin can which was then sealed under vacuum and stored at 40°, 72° or 100° F. (4.4°, 22.2° or 37.8° C.) to permit transfer of moisture among the components. After storage for periods up to 5 months, the cans were opened and the new moisture content of each component was determined.

RESULTS AND DISCUSSION

The 5 components of a chicken stew were stored in baskets at 72° F. and the extent of moisture transfer was determined. Table 1 compares the results with predictions based on the application of equations 1 and 4 to the moisture sorption isotherms. The preliminary estimate of R (equilibrium relative humidity) in this example was 13.4%. The large difference between this estimate and the final value of 7.6%

TABLE 1

Predicted and observed moisture transfer in precooked dehydrated chicken stew mixture at 72° F.

Ingredient	Weight	Relative humidity, %		Moisture, % of solids		
		Initial	Final predicted	Initial	Final	
					Predicted	Observed
	(grams)					
Chicken	39.9	1.1[1]	7.6	1.07	3.17	3.18
Potato Dice	30.1	28.4	7.6	5.88	3.45	3.64
Lima Beans	15.2	7.7	7.6	3.68	3.68	3.90
Cream Sauce Base	5.0	18.8	7.6	3.49	2.60	2.54
Chicken Soup and Gravy Base	4.0	37.0	7.6	2.49	1.17	1.19
Mixture, calculated total moisture, grams				2.90	2.94	3.03

[1] Extrapolated value.

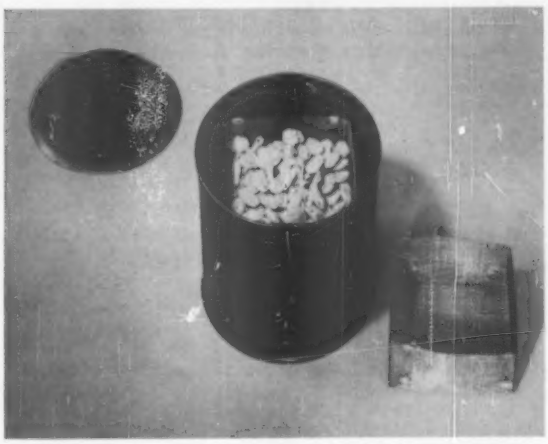

Figure 3. Wire-screen baskets and packaging arrangement for determining extent of moisture transfer among foods.

did not impair the accuracy of the method and the predicted final moisture contents were essentially correct. In this example the final moisture content of the chicken was considerably above the recommended maximum of 1.5%.

Table 2 shows the predicted and observed final moisture contents for the beans and meat of a chili mixture at 72° F. This is an example of moisture migrating from a component of lower moisture content to one of higher moisture content. The ground beef had a higher than usual moisture content initially, but was desiccated to a lower moisture content by the beans. The possibility exists, then, of completing the drying of heat-sensitive materials by combining them in the package with other foods of lower moisture-vapor pressure.

Figure 4 shows the isotherms for the meat and beans in Table 2 and illustrates the difference in relative humidities.

Table 3 shows the predicted and observed final moisture contents for three components of a chili mixture stored at 40°, 72° and 100° F. This example demonstrates a difficulty encountered with unstable materials. The greatest error was in the prediction for the spice mix at 100° F. At this temperature the spice mix browned visibly and caked slightly. The two principal ingredients of the spice mix are tomato solids and soup and gravy base. Tomato solids contain approximately 50% of reducing sugars, and soup and gravy base is approximately 20% hydrolyzed protein. Sugar dehydration and sugar-amine condensation involved in the browning reaction lead to the production of water, carbon dioxide and possibly other volatiles. Crystallization of sugar also releases water. All of these contribute to increased analytical

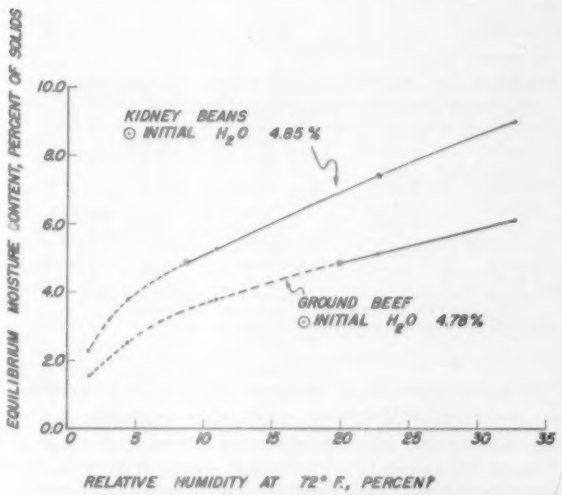

Figure 4. 72° F. isotherms for precooked dehydrated ground beef and kidney beans. Solid lines indicate adsorption; broken lines indicate desorption.

TABLE 2

Predicted and observed moisture transfer in precooked dehydrated mixture of ground beef and kidney beans at 72° F.

Ingredient	Weight	Relative humidity, %		Moisture, % of solids		
		Initial	Final predicted	Initial	Final	
					Predicted	Observed
	(grams)					
Kidney Beans	97.0	8.8	11.1	4.85	5.30	5.33
Ground Beef	41.4	19.9	11.1	4.78	3.71	3.68
Mixture, calculated total moisture, grams				6.38	6.37	6.38

TABLE 3

Predicted and observed moisture transfer in precooked dehydrated chili mixture at 40°, 72° and 100° F.

Ingredient	Weight	Moisture, % of solids					
		Initial	Final				
			40° F.		72° F.	100° F.	
			Predicted	Observed	Predicted	Observed	Predicted	Observed
	(grams)							
Small Red Beans	58.8	7.03	5.85	5.80	5.82	5.53	5.69	5.69
Ground Beef	35.5	0.61	3.29	3.55	3.40	3.42	3.66	3.66
Spice Mix	15.9	3.03	2.81	2.90	2.75	3.26	2.86	3.70
Spice Mix, stored separately		3.03	.....	3.06	.....	.....	.....	3.80

moisture content not accounted for by the theoretical estimation of moisture transfer. This was demonstrated by storing each of the ingredients alone at 40° and at 100° F. The moisture content of the beans and of the ground beef remained unchanged at both temperatures. Table 3 shows that the moisture content of the spice mix also remained constant at 40° F. At 100° F., however, it increased by an amount which accounts for the discrepancy between the predicted and observed values in the mixture. Because of the relatively small proportion of spice mix the extra water had little effect on the other components.

The final moisture content of the ground beef in this example exceeded the recommended limit of 2.25% on a fat-free basis.

Table 4 shows predicted and observed moisture values in a mixture of macaroni and cheese at 72° F. The values under "A" were computed from isotherms

TABLE 4

Predicted and observed moisture transfer in precooked dehydrated mixture of macaroni and cheese at 72° F.

Ingredient	Weight	Moisture, % of solids			
		Initial	Final		
			Predicted		Observed
			A	B	
	(grams)				
Macaroni	40.0	7.51	7.26	7.20	7.30
Cheese	15.0	1.70	2.26	2.49	2.29

A—from isotherms for these lots of macaroni and cheese.
B—from isotherms for other lots of macaroni and cheese.

for the particular lots of macaroni and cheese in question. Vapor-pressure data were also available for other, similar lots of macaroni and cheese and these were used for computing the values under "B." The agreement between predicted and observed values was almost as close for column B as for column A.

Table 5 is a similar comparison of predicted and observed moisture values in a chicken stew combination at 72° F. Columns A and B have the same significance as the corresponding columns in Table 4. These examples demonstrate the possibility of using moisture-vapor pressure data on given lots of foods for computing moisture transfer among other lots of

TABLE 5

Predicted and observed moisture transfer in precooked dehydrated mixture of chicken, potato dice and lima beans at 72° F.

Ingredient	Weight	Moisture, % of solids			
		Initial	Final		
			Predicted		Observed
			A	B	
	(grams)				
Chicken	41.0	1.55	2.85	2.96	2.91
Potato Dice	30.2	6.20	4.30	4.10	4.45
Lima Beans	13.9	3.91	3.85	3.98	3.72

A—from isotherms for these lots of chicken, potatoes, beans.
B—from isotherms for other lots of chicken, potatoes, beans.

the same foods which are similar in composition and processing.

SUMMARY

Dehydrated foods normally have good shelf life if the moisture content is maintained within narrow limits. Stability is impaired in mixtures of dehydrated foods in which there is a transfer of water from items of higher moisture-vapor pressure to those of lower moisture-vapor pressure.

Isotherms which show the relationships between moisture content and vapor pressure (or relative humidity) of the components of a food mixture provide guidance as to their packaging compatibility. A formula is presented for computing from the isotherms the equilibrium relative humidity of such mixtures and the final equilibrium moisture content of each component. Data are presented which show the close agreement between final moisture contents calculated by the formula and values determined experimentally.

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The Effect of Grade, Weight and Class of Beef Carcasses upon Certain Chemical and Sensory Evaluations of Beef Quality[a, b]

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(Manuscript received July 8, 1958)

GRADE, CLASS, AND WEIGHT are all contributing factors in determining price of beef carcasses and are so considered since each is felt to have some effect on either the yield of edible product or on the final eating qualities. The effect of grade, class, and weight upon yield of prefabricated beef cuts has been reported in a previous paper *(4)*.

This article reports on the effect of grade, class, and weight upon sensory flavor, tenderness, juiciness and over-all acceptance and upon percentage ether extract in the loin eye sample and mechanical shear value.

MATERIALS AND METHODS

A total of 334 beef carcasses were used. These carcasses represented the Choice, Good and Commercial (also Standard) grades and included steer, heifer, and cow classes in 400 to 500, 600 to 700, and 800 to 900 pound carcass weight groups, where possible *(4)*.

Carcasses were chosen by a U.S.D.A. Grading Service representative to fit the middle of the specified grade.

After a 24- to 48-hour chill, carcasses were cut according to the method described *(4)*. Two adjacent loin strip steaks were removed, wrapped and freezer-stored at −20° F. until being randomly withdrawn for testing. One steak was used for the determination of sensory acceptance, tenderness, flavor, and juiciness. These sensory evaluations were conducted by the Food Acceptance Branch, Quartermaster Food and Container Institute for the Armed Forces. A randomly selected panel was used to evaluate over-all acceptance, whereas a selected trained panel was used to evaluate sensory tenderness, flavor, and juiciness. The nine-point hedonic scale was used to evaluate sensory preference or acceptance, while other structured scales were used to evaluate tenderness, flavor, and juiciness (see Table 1). In converting these responses to numerical values for statistical analysis, highest ratings were assigned to the most desirable end of each scale. Withdrawal of steaks for testing was randomized to minimize the effect of environment, individual preference, and preparation upon final results. Steaks were grilled to a like degree of "doneness" as determined by appearance and internal temperature which was observed by use of thermocouples.

The second loin strip steak was used for chemical analysis and to provide cores for mechanical shear evaluations. Steaks were removed from the freezer and allowed to temper at room temperature for 45 minutes or until soft enough to remove cores. Six ½-inch cores were removed from each tempered loin strip steak, the cores allowed to thaw completely, and then chilled at 40° F. for one hour. Samples were cooked in a 158° F. water bath for exactly 3 minutes and then stored overnight at 40° F. in a closed container to preclude moisture loss. Shear values were obtained with a Warner-Bratzler shear machine.

Ether extract content of a loin eye sample was determined by the A.O.A.C. procedure.

The analysis of variance was used to determine if differences existed between grades, classes, and weight groups with regard to the sensory and chemical factors reported (Table 3). In making the comparison between grades, data were used only from steer carcasses weighing 400 to 500 and 600 to 700 pounds, heifer carcasses weighing 400 to 500 pounds, and cow carcasses weighing 600 to 700 pounds, since these are the only groups found in all three grades. For a similar reason, only Choice and Good carcasses weighing 600 to 700 pounds and Commercial (Standard) carcasses of 400 to 500 pounds were considered in making the comparison between steers, heifers, and cows. In making the weight analysis, data from Good and Choice steers were used. A separate analysis of variance was used for analyzing for differences between grades, classes, and weight groups. In each analysis, the other two treatment variables were ignored when analyzing for differences in one given variable, since there were too many missing groups to perform a factorial analysis.

TABLE 1

Sensory evaluations of steaks
Rating scales used

Numerical score	Sensory acceptance	Sensory flavor	Sensory juiciness	Sensory tenderness
1	Dislike extremely	Extremely poor	No juiciness	Extremely tough
2	Dislike very much	Very poor	Slight juiciness	Very tough
3	Dislike moderately	Poor	Moderate juiciness	Moderately tough
4	Dislike slightly	Below fair above poor	Much juiciness	Slightly tough
5	Neither like nor dislike	Fair	Extreme juiciness	Slightly tender
6	Like slightly	Below good above fair		Moderately tender
7	Like moderately	Good		Very tender
8	Like very much	Very good		Extremely tender
9	Like extremely	Excellent		

RESULTS AND DISCUSSION

In this study, sensory acceptance as determined by the nine-point hedonic scale was not significantly affected by grade (Table 3). There was a tendency

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TABLE 2
Sensory and chemical evaluations[1]
Lot averages

Number of animals	Grade	Class	Carcass weight	Sensory acceptance [2]	Sensory flavor [3]	Sensory juiciness [4]	Sensory tenderness [5]	Mech. shear value [6]	Ether extract
			cwt.						%
20	Choice	Steer	4–5	7.09	6.75	3.00	4.75	8.25	6.74
20	Choice	Steer	6–7	7.05	5.90	3.15	4.90	8.49	6.91
20	Choice	Steer	8–9	6.42	6.35	2.95	4.55	8.16	9.42
20	Choice	Heifer	4–5	7.20	6.50	2.95	4.90	8.27	7.18
20	Choice	Heifer	6–7	7.95	6.75	3.25	5.45	7.60	8.33
20	Choice	Cow	6–7	8.15	6.50	3.05	5.25	7.20	8.12
20	Good	Steer	4–5	7.70	6.15	2.80	4.50	8.93	4.66
20	Good	Steer	6–7	6.45	5.80	2.80	4.45	9.03	5.63
20	Good	Steer	8–9	6.70	6.25	3.05	4.35	9.33	8.17
20	Good	Heifer	4–5	7.15	6.05	2.60	4.30	9.44	4.71
20	Good	Heifer	6–7	7.10	6.45	2.80	4.55	9.10	5.09
20	Good	Cow	6–7	7.30	6.40	2.95	5.05	8.63	7.22
21	Com'l	Steer	4–5	7.05	6.25	2.70	3.95	10.22	3.03
20	Com'l	Steer	6–7	7.00	6.15	2.70	3.90	10.60	3.60
14	Com'l	Heifer	4–5	7.43	6.14	3.00	4.86	9.27	4.57
20	Com'l	Cow	4–5	7.20	5.80	2.95	4.95	9.28	4.10
20	Com'l	Cow	6–7	6.80	6.15	2.80	4.30	9.65	9.09

[1] Values determined on loin eye (*Longissimus dorsi*) samples.
[2] Based on 9-point hedonic scale (See Table 1).
[3] Based on a 9-point subjective scale.
[4] Based on a 5 point subjective scale.
[5] Based on an 8-point subjective scale.
[6] Expressed in pounds of shear force.

toward higher ratings for Choice grade steaks. However, because of tremendous individual variation, this was not significant. Individual variation may have resulted partly from differences in individual preference, environment, etc., as well as inherent differences in the steaks. However, a highly significant difference due to classification or weight of carcass was noted. A higher preference was indicated for loin strip steaks from cows or heifers as compared to steers. A higher preference was also shown for steaks from 400 to 500 pound carcasses when compared to those from heavier cattle. Wanderstock and Miller *(7)* previously reported a difference between two groups of carcasses that varied in grade, with a preference for the higher grade. However, Aldrich and Lowe *(1)* failed to note a difference in "palatability" between beef round cuts from the Good *versus* the Choice grade.

Flavor and juiciness were not significantly affected by either carcass grade, class, or weight. Again, a tremendous variation existed in individual values for flavor and juiciness, resulting in lower variance ratios. Wanderstock and Miller *(7)* reported a grade difference with regard to flavor, tenderness, and juiciness, but Aldrich and Lowe *(1)* uncovered no difference between Good and Choice round cuts when flavor and juiciness were compared. Jacobson and Fenton *(3)* found juiciness to decrease with age.

Carcass grade exerted a highly significant effect upon tenderness as determined by either a mechanical shear value or a sensory evaluation. Higher graded steaks were more tender. Similar findings have previously been reported by Wanderstock and Miller *(7)* and Paul and Bratzler *(5)*. Wierbicki *et al. (8)* reported that carcass grade was closely related to tenderness in samples of 3 days post mortem, but less closely related at 15 days post mortem. Perhaps the reason why a difference is noted in tenderness, but not in over-all acceptance is the fact that a trained panel was used for determination of sensory tenderness, whereas an untrained panel was used to indicate over-all acceptance. The trained panel may have been more sensitive in determination of a given sensory aspect. Raffensperger and Pilgrim *(6)* have given some indication of the superiority of a trained, selected panel. Class of carcass exerted a significant effect upon sensory tenderness and shear value. Higher tenderness scores and corresponding lower shear values were found for cows and heifers. Carcass weight failed to show a significant effect on either tenderness determination. Hankins *(2)* stated that

TABLE 3
Yield summaries and statistical analysis of sensory and chemical evaluations
All determinations based on loin eye samples

Grade comparison [1]	Average values			
	Com'l	Good	Choice	F Value
Sensory acceptance	7.04	7.15	7.52	2.12
Sensory flavor	6.12	6.10	6.41	1.33
Sensory juiciness	2.78	2.79	3.04	3.02
Sensory tenderness	4.20	4.58	4.95	4.84**
Mechanical shear value	9.99	9.01	8.18	20.39**
Ether extract (%)	5.05	5.65	7.21	11.74**
Class comparison [2]	**Cow**	**Heifer**	**Steer**	**F Value**
Sensory acceptance	7.55	7.49	6.85	4.38**
Sensory flavor	6.23	6.48	5.98	2.06
Sensory juiciness	2.98	3.02	2.88	0.54
Sensory tenderness	5.08	4.96	4.43	3.31*
Mechanical shear value	8.54	8.59	9.25	3.42*
Ether extract (%)	6.31	6.26	5.21	3.94*
Weight comparison [3]	**4–5**	**6–7**	**8–9**	**F Value**
Sensory acceptance	7.69	6.75	6.56	5.18**
Sensory flavor	6.45	5.85	6.30	2.09
Sensory juiciness	2.90	2.98	3.00	0.20
Sensory tenderness	4.62	4.68	4.45	0.27
Mechanical shear value	8.59	8.76	8.75	0.14
Ether extract (%)	5.64	6.03	8.64	15.43**

* Indicates significance at 5% level of probability.
** Indicates significance at 1% level of probability.
[1] Grade comparison includes steers (4–5 and 6–7 cwt.), heifers (4–5 cwt.) and cows (6–7 cwt.).
[2] Class comparison includes Choice (6–7 cwt.), Good (6–7 cwt.) and Commercial (4–5 cwt.).
[3] Weight comparison includes Good and Choice steers.

meat tenderness tended to vary with age of the animal from which the carcass was obtained. Perhaps Federal grade standards have a compensatory effect for heavier carcasses so that a weight effect was not shown. In other words, heavier carcasses need more finish and quality to be included in the same grade, therefore, this additional finish and quality compensated for the possible effect of heavier carcass weight. Perhaps, if various carcass weight groups were equalized with regard to marbling or other subjective quality factors when being compared, then a weight effect might be observed upon tenderness.

Weight was found to have an effect on preference but not upon either flavor, juiciness, or tenderness. Thus, it is difficult to speculate as to which factors were responsible. Perhaps the effect on preference was an accumulative effect of the other factors. The effect of either grade, class, or weight upon preference closely paralleled their effect upon tenderness.

Ether extract of the loin eye *(Longissimus dorsi)* sample revealed that differences were attributable to grade, class, and weight. High to low values were found in Choice, Good, and Commercial steaks, in that order. Less difference was found between Commercial and Good than between Good and Choice. This is undoubtedly because some heavy cow carcasses were included in the Commercial group. These cattle need more marbling to qualify for this grade, according to the Federal grade standards. Cows and heifers displayed equal levels of loin eye ether extract, and both contained more marbling in loin eye steaks than steers. Marbling also markedly increased with carcass weight. The largest difference existed between the 600 to 700 pound and the 800 to 900 pound weight groups. Jacobson and Fenton *(3)* have previously reported increased fat in *Longissimus dorsi* samples as age of animal increased. Age of animal should closely parallel carcass weight, so essentially this study concurs with results of Jacobson and Fenton.

U.S.D.A. grade standards appeared to do a good job of differentiating between various levels of tenderness, as demonstrated both by sensory evaluations and by mechanical shear results. This was paralleled by definite increases in loin eye ether extract in the higher grades. Perhaps the differences in marbling were partly responsible for the differences in tenderness.

Steaks from steer carcasses represented in this study received a lower acceptance rating than those from cow or heifer carcasses. A lower tenderness score and a higher shear value was also shown in the steer classification, as well as a lower average ether extract value. Perhaps the standards are too easy on steer carcasses. An objective evaluation of tenderness may do a superior job of categorizing carcasses with regard to final eating qualities; regardless of class, grade, or weight.

Weight affected acceptance score. The only other factor similarly and significantly affected by weight groups was percentage ether extract in the loin eye sample.

SUMMARY

The effect of carcass weight, grade, and class upon sensory acceptance, flavor, juiciness, and tenderness, mechanical shear value, and percentage ether extract has been shown.

Higher ether extract values, lower shear values, and higher tenderness ratings were associated with higher grades.

Steaks from steer carcasses showed lower acceptance and tenderness ratings, lower ether extract content and higher shear values than those from cows and heifers.

Steaks from 400 to 500 pound carcasses received highest acceptance ratings, when weight groups were compared. Highest ether extract of the loin eye (marbling) was found in the heaviest carcasses.

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Effect of Borates and Other Inhibitors on Enzymatic Browning in Apple Tissue[a, b]

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MANY FRUITS and vegetables are susceptible to rapid discoloration following mechanical or physiological injury. The reaction responsible for this is an enyme-catalyzed oxidation of phenolic compounds. Discoloration, or browning, can be controlled by inactivating the enzyme or by maintaining the polyphenols in a reduced state. Inactivation of the enzyme phenoloxidase may be accomplished by heating the product, as in blanching *(4)*. However, this causes loss of firm texture, leaching of the water soluble components, and destruction or loss of vitamins. Ascorbic acid and sulfur dioxide have been used to maintain the polyphenols in a reduced state *(2)*. But ascorbic acid has two disadvantages in that the protection is not permanent, and the breakdown products are precursors of non-enzymatic browning reactions. Sulfur dioxide imparts an objectionable flavor and may bleach the natural color of the food—which is sometimes undesirable.

The purpose of this study was to investigate the properties of boric acid and borate salts as inhibitors of enzymatic browning of apple tissue. By chemically complexing the oxidation site on the polyphenol, the o-dihydroxy group, and thus blocking the oxidation of the polyphenols, the borates can inhibit enzymatic browning *(6)*. Boric acid and borate salts are, of course, not presently approved for use by the Food and Drug Administration. However, the inhibition of enzymatic browning by masking the oxidation site is of interest regardless of the immediate applicability of the particular complexing agent being used.

In this study, apple tissue was treated with solutions of several different borates and other compounds singly and in various combinations. Each solution was evaluated according to its effectiveness in retarding browning. Those solutions which showed promise in preserving color were evaluated for their effect on flavor, texture and off-flavor as well. Solutions containing 0.5% sodium tetraborate and either 0.5% ascorbic acid or 100 p.p.m. sulfur dioxide imparted good browning control without adverse effect on other organoleptic properties.

EXPERIMENTAL PROCEDURE

Preparation of treatment solutions. All chemicals used in the study, except sucrose, were of reagent purity. Sucrose was of commercial grade; distilled water was used as the solvent. Sodium tetraborate, sodium metaborate, sodium perborate and boric acid were used as the borate salts in the initial phase of the work. Concentrations were calculated on a weight to volume basis, based on the weight of salt added rather than weight of borate ion.

Malic acid was used to buffer solutions at pH 3.5. Sodium bisulfite salt served as the source of sulfur dioxide in solution.

Treatment of apple slices. Stayman Winesap apples were used in all studies except the general acceptability study. This variety is regarded as having a very active phenolase system as evidenced by the rapid browning of the exposed cut surface *(3)*. All apples were obtained at the same time from one grower. They were stored at 34–36° F. for the duration of the study.

For each study, apples were randomly selected from the supply in storage. They were washed by hand with water, and peeled, cored and sliced mechanically. Apples were examined before and after the slicing operation for any evidence of brown spots due to bruising and mishandling. These brown spots were removed to assure that all evidences of browning noted upon examination after storage of the slices took place after the experimental treatments. Apple slices were held in a 0.5% NaCl solution to retard browning prior to treatment. Before each experimental treatment the salt solution in which the apple slices were being held was drained from the slices. Apple slices were then placed on an aluminum screen and rinsed freely with cold tap water to remove residual salt.

Approximately 200 g. of the desalted apple slices were placed in a 1000 ml. beaker containing 500 ml. of the treatment solution. Aluminum wire screens were placed on the slices to keep them submerged. The beakers were placed in a vacuum chamber and 27–28 inches of vacuum drawn and held for 15 minutes to facilitate the movement of the solution into the slices. After removal of the samples from the vacuum chamber, the solutions were drained through a colander. The slices were packaged in polyethylene bags and placed in storage at 45° F. for 48 hours. Under these conditions the browning development was slow enough so that differences could be noted without unduly prolonging the experimental time.

Evaluation of slices treated with different chemicals. After 48 hours at 45° F., the slices were removed from the packages and placed before a panel of 8 experienced judges for color evaluation. The panel graded the slices for color on the basis of 1 to 10, a score of 10 representing good apple color and 5, borderline acceptability.

General acceptability study. In the general acceptability study, the Jonathan variety was used because the Staymans had become overmature in storage and were quite flavorless. The purpose of this study was to determine the effect of the chemical complexing agents on apple flavor in general.

Jonathan apples, which had been in storage for 6 months at 34° F., were divided into 3 lots, one for each replication. Each replication was processed independently; all 3 replications were processed on the same day. Four treatment solutions were chosen from among those investigated above and 6 samples of each treatment, one for each examination period, were prepared for each replication. Thus, there were 24 samples in each replication and 72 samples in the entire study.

The apple slices were prepared and treated as described previously. After being packaged, they were placed in storage at 45° F. During the 14-day storage period, examinations were made after 2, 5, 7, 9, 12 and 14 days in storage. On each examination day, 12 samples, one for each treatment and replication, were removed from storage and placed before panel members.

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[b] Submitted by the senior author in partial fulfillment of the requirements for the Ph.D. degree in Food Technology, University of Illinois, Urbana.

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Samples of each treatment were evaluated for flavor, color, texture, and off-flavor. The same grading scale was used.

RESULTS AND DISCUSSION

Effect of boric acid and borates. Enzymatic browning in apple slices was completely inhibited by treatment with 1.5% sodium tetraborate (STB) or sodium metaborate (SMB) solutions. Borate-treated had more natural apple color than sulfiite-treated slices, which were bleached colorless. In those slices treated with solutions containing 0.5% or less of STB or SMB, there was evidence of some browning, but the inhibition effect was still obvious. These samples were definitely better than the untreated control.

Sodium perborate (SPB) solutions ranging in concentration from 0.1% to 1.5% were not effective in inhibiting enzymatic browning. Rather than the continuous, even brown color of the untreated slices, a discontinuous, uneven browning was observed in SPB treated samples. Possibly, polyphenols were oxidized by the perborate itself. There was no evidence of browning inhibition in any of the samples treated with boric acid, 0.1 to 1.5%.

Effect of pH on STB activity. The difference in activity between the borate salts (SMB and STB) and boric acid may be ascribed to the fact that the complex formation between borates and polyhydric compounds is favored by the presence of an alkaline pH. Borate salts are buffers in the pH range of 8.5–9.0 whereas the pH of boric acid in solution is around 5.0. Phenolase-catalyzed oxidation of polyphenols is inhibited by acid pH. Thus, from the point of view of complex formation, alkaline pH would be desirable in the treatment solutions while acid pH would be desirable in order to inhibit phenolase activity. Therefore, it was of interest to determine the pH of the STB solution showing optimum inhibition of enzymatic browning.

Apple slices were prepared and treated with these solutions of 1.0% STB adjusted to pH 8.7, 7.7, 6.1, 4.7, and 3.9 by addition of 1 N HCl. There were no observable differences among the different treatments. Measurements of apple tissue pH indicated that the natural buffer system of the apples kept the pH of the apples at its natural level of about 3.5. Further, it was possible that the decrease in polyphenol-borate reaction at acid pH was compensated by the decrease in phenolase activity which also accompanies a decrease in pH.

Effect of other reagents on STB activity. Since STB was shown to be so effective in retarding enzymatic browning, it was considered desirable to learn whether some of the common food additives might act synergistically with STB in this respect and thus lower the concentration required. The results with each will be discussed separately.

1. *Citric acid*

Solutions containing citric acid in concentrations to 0.5% alone or in combination with 2.0% disodium phosphate (DSP), 0.5% STB or 2.0% DSP plus 0.5% STB were used to treat slices. Results are shown in Table 1. From these data one can conclude that citric acid alone is not an inhibitor of enzymatic browning in apple slices, and that it actually seems to catalyze the browning process. These findings are in agreement with the previous work of Olander *(3)* and Strachan and Moyls *(5)*.

TABLE 1

Effect of citric acid, disodium phosphate and sodium tetraborate on the color score of apple slices

Citric acid concentration	Nothing added	Plus 2.0% DSP	Plus 0.5% STB	Plus 2.0% DSP and 0.5% STB
	Color scores			
%				
0.0	3	7	5	8
0.05	2	7	5	8
0.25	1	5	3	7
0.5	1	5	3	7

2. *Disodium Phosphate*

It can be noted in Table 1 that DSP at 2.0% concentration alone gave fair protection against browning and in combination with 0.5% STB gave good protection. This suggested that a separate experiment to evaluate these reagents alone and in combination at several concentrations would be interesting.

Results are shown in Table 2. DSP had an inhibitory effect on enzymatic browning development in apple tissue. The concentrations of DSP necessary were 1.5 to 2.0%. STB and DSP acted synergistically as browning inhibitors. In an 0.25% STB solution, the addition of 1.5 and 2.0% DSP gave acceptable samples; with 0.5% STB, only 1.0% DSP was necessary to satisfactorily inhibit browning. Similiar results were obtained when this study was repeated at pH 3.5 with malate buffer.

Since the 2.0% DSP in combination with STB gave such good protection against browning, it was desired to determine whether other inhibiting agents

TABLE 2

Effect of disodium phosphate and sodium tetraborate on the color score of apple slices

DSP	% STB			
	0.0	0.1	0.25	0.5
	Color scores			
%				
0.0	3	3	3	5
0.5	3	3	3	5
1.0	4	4	4	7
1.5	5	5	6	8
2.0	7	7	8	9

TABLE 3

Effect of several inhibiting agents in combination with 2.0% disodium phosphate at pH 5.0 on the color score of apple slices

Agent	Concentration	Color score
Sodium tetraborate	0.5%	9
Sodium chloride	0.5%	8
Sucrose	5.0%	6
Ascorbic acid	0.1%	8
Sulfur dioxide	50 p.p.m.	7
None	.....	7

added to DSP could serve as well as STB. Results of such an experiment are shown in Table 3. It was found that 5.0% sucrose and 50 p.p.m. SO_2 were of no aid to the DSP. Although 0.5% NaCl and 0.1% ascorbic acid gave slight improvement over the DSP control, in neither case was the color score quite as good as when DSP and STB were used.

3. *Ascorbic Acid*

Ascorbic acid can retard enzymatic browning by reducing the O-quinone formed during the enzyme-catalyzed oxidation of the polyphenol to a reduced, colorless state. Data on the effectiveness of ascorbic acid alone and in combination with STB on inhibition of browning are shown in Table 4. It is evident that pH had an effect on the browning inhibition action of both solutions and that the anti-browning activity was optimum at pH 5 and 7. Addition of STB to solutions of ascorbic acid inhibited the browning completely in apple slices at pH 5 and 7. STB added to ascorbic acid at pH 3 and 9 improved the appearance of the slices over that obtained by ascorbic acid alone, but a slight amount of browning was still evident.

TABLE 4

Effect of 0.25% ascorbic acid alone and in combination with sodium tetraborate at several pH levels on the color score of apple slices

STB	pH	Color score
%		
.....	3	3
.....	5	7
.....	7	7
.....	9	6
0.5	3	8
0.5	5	9
0.5	7	9
0.5	9	7

4. *Sodium Chloride*

Since NaCl has been reported as an effective browning inhibitor *(2)*, and since 0.5% NaCl solution was used as a browning inhibitor in holding apple slices prior to treatment, a study was carried out to determine whether there is synergistic activity between NaCl and STB. Results are shown in Table 5. Application of NaCl alone resulted in unacceptable samples. The effect of NaCl on STB activity can be seen by the improvement in the color scores of samples as the concentration of NaCl was increased. The combination of 0.5% NaCl and 0.5% STB prevented severe browning development.

TABLE 5

Effect of sodium chloride and sodium tetraborate at pH 3.5 on the color score of apple slices

NaCl	STB	Color score
%	%	
0.0	.....	1
0.1	.....	3
0.25	.....	3
0.5	.....	4
0.0	0.25	3
0.1	0.25	3
0.25	0.25	4
0.5	0.25	6
0.0	0.5	4
0.1	0.5	4
0.25	0.5	5
0.5	0.5	7

5. *Sucrose*

Sugars and sugar solutions have been recommended for use in frozen fruits to inhibit browning *(1)*. It is believed that sugar solutions may inhibit discoloration by their effect in reducing the concentration of dissolved oxygen and reducing the rate of diffusion of the oxygen of the air into the fruit tissues *(2)*.

In preliminary investigations on the effect of sugars, both sucrose and dextrose were used, but since there was no difference in their behavior, it was decided to use only sucrose in further work as indicated in Table 6.

Sucrose and STB did complement each other as browning inhibitors. The effect of sucrose on the activity of STB can be seen by comparing the color scores of the samples as the concentration of sucrose was increased. The addition of STB to sucrose improved the color of the samples over that of sucrose alone, but increasing the concentration of STB from 0.25% to 0.5% did not enhance the browning inhibition significantly. The combination of 15% sucrose and 0.25% STB gave acceptable samples.

TABLE 6

Effect of sucrose and sodium tetraborate at pH 3.5 on the color score of apple slices

Sucrose	STB	Color score
%	%	
0.0	.....	1
5.0	.....	2
10.0	.....	3
15.0	.....	5
0.0	0.25	2
5.0	0.25	3
10.0	0.25	6
15.0	0.25	7
0.0	0.5	3
5.0	0.5	4
10.0	0.5	6
15.0	0.5	7

Sulfur dioxide. The ability of SO_2 to inhibit enzymatic browning is well established *(2)*. Therefore, it was of interest to observe the effect on STB activity of SO_2 as obtained by adding sodium bisulfite to the solution.

Optimum pH of SO_2 when used as the sole inhibitor of enzymatic browning (Table 7) was found to be in the range of pH 4–5. Apple slices treated with SO_2 at pH 3 received a score of 8 while those slices treated at pH 4 and 5 were rated 9. At pH values greater than 5, the slices were extremely poor in color.

STB and SO_2 interacted at pH 3.5 to inhibit enzymatic browning. This is shown in Figure 1, for which the sample treatments and color scores given are shown by corresponding numbers in Table 8. The effect of SO_2 on STB activity can be seen by comparing the color scores of the samples at constant STB concentration as the concentration of SO_2 was increased. A treatment solution containing 0.5% STB

TABLE 7

Effect of pH on inhibition of browning by a solution containing 150 p.p.m. sulfur dioxide

pH	Color score
3.0	8
4.0	9
5.0	9
6.0	2
7.0	3
8.0	3
9.0	2

and 75 p.p.m. SO_2 inhibited browning completely whereas there was browning in slices treated with 100 p.p.m. SO_2 alone. The important point here is that 100 p.p.m. concentration is far below the taste threshold for SO_2 whereas incorporation into the apple tissue of sufficient sulfite to inhibit browning without the aid of STB would require so high a concentration that an undesirable taste would be imparted to the product.

General acceptability study. The following treatment solutions buffered at pH 3.5 with malic acid were employed:

a—100 p.p.m. SO_2
b—0.5% ascorbic acid
c—100 p.p.m. SO_2 + 0.5% STB
d—0.5% ascorbic acid + 0.5% STB

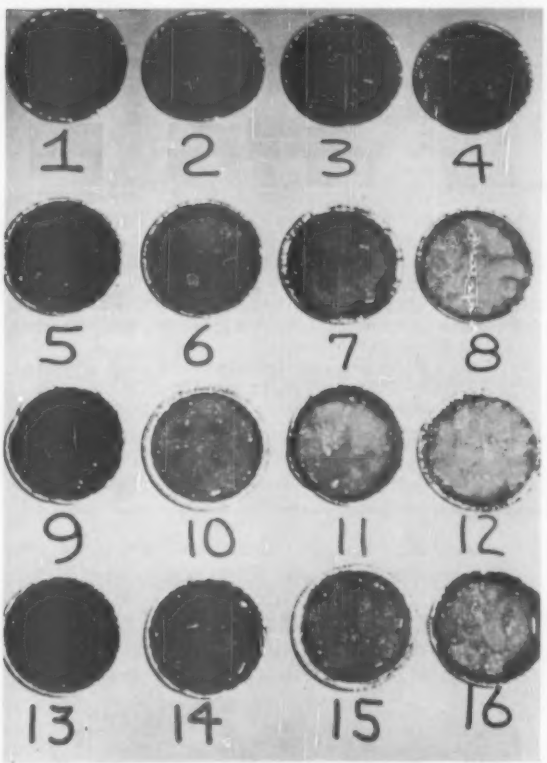

Figure 1. Samples treated with various concentrations of sodium tetraborate and sulfur dioxide. Treatments and scores are shown in Table 8.

The standard procedure was used for preparation of the samples which were packaged in polyethylene bags and stored at 45° F. for various times up to 14 days. At designated storage periods the samples were evaluated organoleptically for flavor, color, texture and off-flavor by the 8-member panel. Scores for the 3 replications were averaged and are shown in Table 9.

TABLE 8

Effect of sulfur dioxide and sodium tetraborate at pH 3.5 on the color score of apple slices

No. of sample shown in Figure 1	STB	P.P.M. SO_2	Color score
	%		
1	0.0	0	1
2	0.0	50	3
3	0.0	75	4
4	0.0	100	6
5	0.1	0	2
6	0.1	50	4
7	0.1	75	5
8	0.1	100	9
9	0.25	0	3
10	0.25	50	5
11	0.25	75	8
12	0.25	100	9
13	0.5	0	4
14	0.5	50	6
15	0.5	75	9
16	0.5	100	9

Eight-taster total organoleptic scores were analyzed statistically for variance. The mean squares for each variable and their level of significance are shown in Table 10.

Effect of treatment on color was significant at the 1% level. Examination of the data, Table 9 shows that the 4 treatments were obviously different. A marked improvement in the color scores was noted when 0.5% STB was included in the treatment solution with sulfur dioxide. Samples treated with STB were better than the others after 2 days in storage, and the difference between samples with and without

TABLE 9

Effect of sodium tetraborate on the activity of ascorbic acid and sulfur dioxide as inhibitors of enzymatic browning

Treatment	Days in storage	Color	Flavor	Texture	Off-flavor
100 p.p.m. SO_2	2	7.1	6.1	6.6	6.6
	5	6.3	6.0	6.6	6.2
	7	6.7	5.7	6.2	5.9
	9	6.3	5.6	6.5	5.9
	12	7.1	5.5	6.5	5.4
	14	6.5	5.1	6.2	5.2
0.5% Ascorbic acid	2	4.7	6.0	6.4	6.5
	5	2.9	5.7	6.4	5.8
	7	2.3	5.6	6.3	5.7
	9	2.3	5.6	6.3	5.8
	12	2.2	3.7	5.7	3.3
	14	1.3	2.0	5.2	2.0
100 p.p.m. SO_2 plus 0.5% STB	2	8.3	6.0	6.5	6.4
	5	8.5	5.7	6.5	6.1
	7	8.4	5.7	6.3	6.0
	9	8.4	5.3	6.5	5.3
	12	8.5	5.6	6.8	5.4
	14	8.4	5.2	6.0	5.2
0.5% Ascorbic acid plus 0.5% STB	2	7.4	5.8	6.8	6.3
	5	5.3	5.5	6.6	5.3
	7	4.4	5.1	6.3	5.2
	9	4.5	5.4	6.3	5.4
	12	4.6	4.9	6.4	4.5
	14	4.5	5.1	6.2	5.0

TABLE 10

Analysis of variance of the general acceptability study

Source of variation	Degrees of freedom	Color	Flavor	Texture	Off-flavor
Treatment	3	7001**	190**	39	242**
Block	2	75	6	18	16
Main plot error	6	20	13	8	9
Storage time	5	277*	269*	48**	476**
Storage time × treatment	15	86**	91**	10	101*
Subplot error	40	30	12	8	51

* Significant at the 5% level.
** Significant at the 1% level.

STB became greater with increase in storage time. The storage time effect is adequately described by quadratic regressions.

Another improvement of the borate treated slices was the uniformity of the browning inhibition. Color scores for the sulfite treated samples fluctuated with time, Table 9. This can be compared to the nearly constant average scores received by the samples treated with STB in addition to the sulfite. The browning in apple slices was completely inhibited by the combination of 100 p.p.m. SO_2 and 0.5% STB throughout the 14-day storage period.

Effect of treatment and storage time was significant on flavor and off-flavor, Table 10. However, it should be pointed out that only the 0.5% ascorbic acid treatment is significantly different from the other treatments, in which the scores are homogeneous. This difference, shown in Table 9, can be readily explained. The sharp drop in flavor and off-flavor values for the ascorbic acid treated slices after 9 days' storage was due to mold development, whereas the apple slices treated with ascorbic acid plus STB, sulfite or sulfite plus STB were still acceptable in flavor and off-flavor due to the anti-fungal properties of the treatment solutions.

In the case of texture, a linear regression adequately describes the effect of storage time. Again, the texture scores for samples treated with 0.5% ascorbic acid were significantly different from the others when the variable of storage time was considered. Perhaps the mold growth which developed after 9 days in the 0.5% ascorbic acid treated samples resulted in a softening of the apple tissue.

CONCLUSIONS

Borate salts were investigated to determine their effectiveness in retarding enzymatic browning of apple slices. Sodium meta- and tetra-borate (STB) were found to be effective inhibitors of enzymatic browning, whereas sodium perborate and boric acid were not effective. Borate activity was not affected by pH.

Study of STB with other inhibitors for apple slice browning indicated favorable interaction of STB with sodium diphosphate, ascorbic acid, sodium chloride, sucrose and sodium bisulfite. Optimum pH range for interaction of ascorbic acid and STB was 5–7. Both sucrose and dextrose were found to be equally effective as browning inhibitors. Activity of sodium bisulfite varied with pH, the optimum being in the acid range.

STB was found to exert no detrimental effect on flavor, texture, or off-flavor. The general acceptability study further showed that 0.5% STB plus 100 p.p.m. SO_2 from sodium bisulfite gave uniformly excellent color protection during the 14 day storage period. The sulfite alone gave fair protection; the combination of STB with ascorbic acid yielded samples slightly below acceptable; and the ascorbic acid alone gave hardly any protection at all.

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What totally will Tora Food add to cereal?
(At a level of 3# to 100#)

Vitamin B_1	163.5 milligrams worth
Vitamin B_2	54.5 milligrams worth
Niacin	408.6 milligrams worth
Vitamin B_6	40.8 milligrams worth
Para-amino benzoic Acid	20.4 milligrams worth
Pantothenic Acid	150.0 milligrams worth
Folic Acid	95.3 milligrams worth
Choline	4.8 grams worth
Inositol	5.4 grams worth
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Here is a nutritional "barrage" that can't help but impress the nutrition-conscious housewife.

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726A

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Sweetness and Acidity Adjustment in Canned Bartlett Pears

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(Manuscript received May 21, 1959)

SWEETNESS AND ACIDITY are important components of flavor in food products, particularly fruits. Basic studies by Valdes *et al. (11, 12)* illustrated the relationship of these factors to "apparent flavor" in both aqueous solutions and natural, homogeneous fruit preparations. The effects of sweetness and acidity on preferences as measured by consumer panels have been reported for peaches, pears, and apricots *(8, 9, 10, 13)*. Preferences for canned orange juices that vary in Brix-acid ratio have been reported by Bayton and Bell and Morse *(2, 7)*. Addition of citric acid to apple sauce with resultant flavor improvement has been reported by Buch *et al. (3)*.

Those studies concerned with sweetness and acidity as they relate to flavor and acceptability have been restricted largely to one raw material source. In a previous study by the authors, it was shown that Bartlett pears from different growing areas vary in the natural level of soluble solids and acid contents *(4)*. Flavor responses by a laboratory taste panel indicated differences in flavor of the pears from the various growing areas. In a consumer study, Pangborn and Leonard *(8)* found preferences for canned Bartlett pears varying in sweetness. They found that the preferred sample in each of two series, representing two growing areas, had approximately the same soluble solids to acid ratio. However, the sweetness and acidity levels, per se, differed.

Pears which are canned commercially are generally processed with a 25° Brix syrup, without consideration of the natural soluble solids and acid contents of the raw material. The present report illustrates the effect of syrup adjustment with varying sucrose or citric acid content on flavor quality of canned Bartlett pears obtained from three growing areas in the state of California. Pears from growing areas which differ in geographical and climatic characteristics may vary in natural soluble solids and acid content. Differences in acid and soluble solids content shown in this paper are representative of the orchards from which fruit was collected but are not necessarily representative of the geographical district by which they are identified.

EXPERIMENTAL PROCEDURE

In the 1957 season Bartlett pears from the Santa Clara, Lake and Placer counties were harvested at a maturity level ranging between 16 and 18.5 pounds pressure, as determined with a Magness-Taylor type pressure tester with a $\frac{5}{16}$ in. plunger. The selection of orchards and districts was made because of inherent differences in the acid content of the pears. After 15 days' storage at 32° F., the pears were ripened at 68° F. and 85% relative humidity until they reached an average ripeness level of approximately 2 pounds pressure. Just prior to canning, each set of pears representative of the 3 growing areas was analyzed for soluble solids and total acid content. Upon determination of these factors and with reference to previous years' variations in these factors among the 3 orchards, appropriate syrups were prepared. These syrups varied in sucrose and/or citric acid concentration in order to obtain canned pears from each area which would equal, approximately, the same Brix-acid ratio of the canned product of the other two areas prepared with the standard syrup of 25° Brix. The pears were peeled, cored, halved, trimmed and sorted before canning. Eighteen ounces $\pm \frac{1}{2}$ ounce of pears and 11 ounces of syrup were added to each No. 2½ can. Segments of pear halves were used to obtain a precise fill weight of 18 ounces. The cans were sealed under 15 inches of vacuum, cooked at 212° F. for 32 minutes in a rotary cooker, cooled rapidly in a rotary water cooler for 7 minutes, and stored at room temperature for subsequent analyses.

Approximately 3 months after canning, the pears were evaluated for flavor by 9 selected and experienced judges. These judges were selected on the basis of acuity and consistency in evaluating canned pears of varying flavor quality, including sweetness and acidity. A balanced incomplete block design was applied whereby 3 samples were presented in each block *(5)*. For each sample presentation in the design, 4 cans of pears were diced and combined with the syrup. The diced pears were served in randomly coded black-lined sauce dishes and evaluated in individual taste booths under low red illumination for masking any effects of possible color variations among samples. The judges ranked 3 samples at each session, a rank of 1 indicating the highest in natural pear flavor quality and a rank of 3, the lowest. The term "natural pear flavor quality" was interpreted by the panel as a balance of the odor and taste components of pears, without excesses or deficiencies of the same. Analysis of variance was applied to the data using the individual judge's total ranks for each sample as the variants. Least significant differences were determined by the procedure outlined by Alder and Roessler *(1)*.

Similar studies as the present one were conducted, in part, during the 1956 and 1958 seasons. The results of these will be discussed in conjunction with the present findings.

RESULTS AND DISCUSSION

Chemical characteristics of the fresh fruit immediately before canning, the canning syrup, and the processed fruit approximately 3 months after canning are shown in Table 1. The effect of growing area on the chemical composition of Bartlett pears is quite evident in regard to total acid content and less evident in soluble solids content. The effect of these variations on the composition of the canning syrup for obtaining similar °Brix-acid ratios in the canned fruit is illustrated.

The resulting nine samples of canned pears were thus divided into two main categories, °Brix-acid ratio and area groups. °Brix-acid ratio groups were (a) 110 to 116, (b) 81 to 97, and (c) 65 to 79. These

TABLE 1

Chemical composition of fresh pears, canning syrup and processed fruit

Samples	Fresh fruit		Canning syrup		Processed fruit		
	°Brix [1]	Total [2] acid	°Brix [1]	Total [2] acid	°Brix [1]	Total [2] acid	°Brix/acid
SANTA CLARA:							
A (control)	13.54	0.26	25	.....	17.11	0.15	115
B	13.54	0.26	25	0.06	17.21	0.18	97
C	13.54	0.26	25	0.18	17.23	0.22	79
LAKE:							
D	14.43	0.35	41	.....	22.58	0.20	116
E (control)	14.43	0.35	25	.....	17.75	0.21	86
F	14.43	0.35	25	0.16	17.52	0.27	66
PLACER:							
G	15.13	0.45	60	.....	30.64	0.28	110
H	15.13	0.45	40	.....	23.44	0.29	81
I (control)	15.13	0.45	25	.....	17.74	0.27	65

[1] Soluble solids measurement by refractometry @ 20° C.
[2] % anhydrous citric acid.

ranges represent the cut-out ratios of pears from the Santa Clara, Lake and Placer areas, respectively, when the fruits from these areas are canned under normal commercial practices with a 25° Brix syrup.

In Table 2 are listed the average flavor ranks for the 9 samples. Also included are the average flavor ranks for the two main categories (°Brix-acid ratio and area). Both were very highly significant factors in affecting flavor differences in the canned product (Table 3). The graphical presentation of results in

TABLE 2

Average pear flavor ranks[1]

°Brix/acid range	Area			Average °Brix/acid [2]
	Santa Clara	Lake	Placer	
110–116	7.89	8.56	11.00	9.15
81– 97	5.56	6.78	8.78	7.04
55– 79	6.44	8.00	9.00	7.81
Average (ar a)[2]	6.63	7.78	9.59	

[1] Based on judges' total ranks. Lowest rank indicates highest flavor level.
[2] Least significant differences: 0.81 @ .05 probability level; 1.08 @ .01 probability level; 1.40 @ .001 probability level.

Figure 1 illustrates these differences. By acidification of pears from the Santa Clara area during processing, an increase in flavor quality was achieved. In contrast, pears from Lake county, when canned under normal canning practices, resulted in highest flavor quality when compared to the canned product which had been adjusted by increase in soluble solids or acid in the canning syrup. A slight increase in flavor quality of pears from Placer county was observed by increasing the soluble solids content in the canning syrup. Analyses of the incomplete series of samples of the 1956 and 1958 seasons resulted in similar observations reported here.

The obvious differences in flavor quality of pears from the three growing areas are more complex than represented by variations in °Brix-acid ratio. One objective explanation is the difference in level of soluble solids (sweetness) and total acidity. This observation has been somewhat borne out in the present study with regard to the pears from the Lake county area. The addition either of citric acid or an elevated

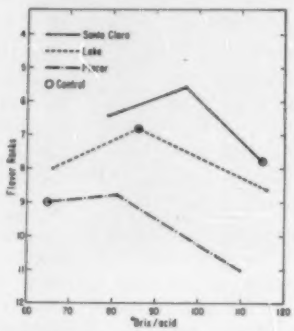

Figure 1. Flavor ranks and ° Brix/acid relationship of pears from three growing areas.

sucrose content in the canning syrup affected flavor adversely, apparently because of changes in levels of sweetness and acidity and the balance of these with other flavor components. Pears from the Placer county orchard were so high in natural total acid that an excess of sucrose in the syrup was required to attain the same °Brix-acid ratio as that of the Lake county pears. The resulting product was probably too sweet, and thus only a slight increase in flavor quality was obtained. When sucrose was added in sufficient quantity to obtain a Brix-acid ratio comparable to Santa Clara pears the flavor was rated poorest of any lot, probably because of the very high sweetness level, with a resulting imbalance of flavor components. The flavor of Santa Clara pears, which have a relatively low total acid content, benefited by addition of acid during processing. Although not enough acid was added at either level to adversely affect flavor in comparison to the control lot, indications were that the highest acid lot (Brix-acid ratio 79) was not as high

TABLE 3

Analysis of variance of flavor ranks

Source of variation	Degrees of freedom	Sum of squares	Mean square	"F" ratio
°Brix/acid range	2	61.56	30.78	13.44 [1]
Area	2	120.52	60.26	26.31 [1]
°Brix/acid × area	4	5.25	1.31	0.57
Error	72	164.67	2.29	

[1] Significant at .001 probability level.

in flavor quality as the middle lot (Brix-acid ratio 97). The results indicate that the laboratory panel associated highest pear flavor with those samples at a °Brix-acid ratio in the range of 81–97.

Attention is called to the fact that a highly experienced and selected laboratory panel evaluated these samples. These results are not to be interpreted as consumer preferences. It has been illustrated that the results of laboratory panels may not necessarily reflect consumer preferences, particularly when factors such as sweetness and acidity are investigated (10). However, since the association of sweetness and acidity with apparent flavor and preference has been demonstrated by both laboratory and consumer panels *(10, 11, 12, 13)*, the principle of adjustment of these components during the canning procedure should result in more consistent, acceptable canned pears from the consumer standpoint. It is conceivable that a consumer panel would prefer the highest °Brix/acid ratio in this series of samples. Consumers have been reported to have preferred canned pears with a °Brix/acid ratio in a range of 138–171 *(10)*.

Since flavor, per se, results from the blend of the non-volatile components, including sweetness and acidity, and the volatile components, the observed flavor differences among pears from different growing areas may be partially attributed to the variations in volatile components, both quantitatively and qualitatively. No information is available on the relationship of tannins to flavor, and only limited work in the field of chemical evaluation of the volatile components in pears is reported *(6)*.

SUMMARY

Bartlett pears grown in three California areas differing in geographical and climatic conditions result in fruits which differ slightly in soluble solids content and markedly in total acid content. Adjustment of these components in the processing of the fruit to the same °Brix-acid ratio does not necessarily result in canned products of similar flavor quality as measured by a selected laboratory taste panel. However, an increase in flavor quality of naturally low acid pears resulted when additional acid was added at the time of processing. A slight increase in flavor quality was achieved when naturally high acid-containing pears were canned with a syrup containing more sucrose than the syrup used in normal commercial practices.

The principle of varying sweetness and acidity in the canning syrup with the levels being dependent on characteristics of the raw fruit proposes one method of obtaining more consistent and acceptable flavor in canned Bartlett pears.

Acknowledgment

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Vanilla Extract: An Improved Lead Number Determination

(Manuscript received May 11, 1959)

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THE LEAD NUMBER of vanilla extract is determined by the method of Wichmann *(5)*. This involves treatment of an extract with a solution of neutral lead acetate under standard conditions. The resulting precipitate is filtered and the lead concentration of the filtrate is determined gravimetrically as the sulfate or the chromate. Either method for the lead determination suffers from the inconveniences of a gravimetric method. Possibilities for error abound in the filtration, ignition and weighings required. In contrast, determination of the lead by titration with ethylenediaminetetraacetic acid (EDTA) *(4)* is rapid, accurate and convenient.

EXPERIMENTAL METHODS

Materials. Extracts one and two were prepared from Bourbon Beans by the standard method of the Flavoring Extract Manufacturer's Association *(3)*. Extracts 3 through 6 are commercial standard strength pure vanilla extracts. Extracts 7 through 11 are commercial ten-fold pure vanillas which were diluted to standard strength (1:9) with 35% (V/V) grain alcohol before analysis. Extract 12 is a commercial standard strength pure extract fortified with one ounce of vanillin per gallon. Extract 13 is a commercial two-fold pure vanilla fortified with two ounces of vanillin per gallon which was not diluted to standard strength before analysis.

Reagents. A 0.025 N EDTA solution prepared by dissolving 9.3025 g. Sequestrene NA_2 Reagent Grade[a] in exactly one l. of deionized water.

A buffer solution consisting of 2 volumes of a 0.1 *N* sodium acetate solution and one volume of a 0.1 *N* acetic acid solution.

An indicator solution prepared by dissolving 0.1 g. Xylenol Orange[b] in 100 ml. 35% (V/V) grain alcohol.

A 1 *N* sodium hydroxide solution.

A 0.1% solution of phenolphthalein in grain alcohol.

Methods. The official method *(1)* was used to prepare 3 sample solutions from each extract. Each triplicate set of sample solutions was prepared simultaneously with a blank determination. The lead concentration of each sample solution and blank was then determined both gravimetrically, as the sulfate by the official method *(2)*, and by an EDTA titration.

In the EDTA determinations 10 ml. of the sample solution was pipetted into a 125 ml. Erlenmeyer flask, one drop of phenolphthalein was added and the solution was made just basic to the indicator with 1 *N* sodium hydroxide. A precipitate [$Pb(OH)_2$] formed at this point. Ten ml. of the buffer solution and 20 drops of the indicator were added and the sample titrated with the EDTA solution. As the titration proceeded the precipitate was redissolved and at the endpoint an abrupt change in the color of the solution from reddish pink to yellow was observed. The blank was conducted in an exactly similar manner.

Calculation

$$\text{Lead number} = \frac{20\ (\text{ml. EDTA consumed})\ (\text{N EDTA})\ 207.21}{1000}$$

$$= 0.1036\ (\text{ml. EDTA consumed})$$

RESULTS

The results are given in Table 1.

[a] Brand of disodium ethylenediaminetetraacetate dihydrate kindly supplied by Geigy Industrial Chemicals, Ardsley, N. Y.
[b] Fisher Scientific Co., Fair Lawn, N. J.

TABLE 1

Extract	Lead number			
	Control	Average	EDTA	Average
1	0.88 0.86 0.86	0.87 ± 0.01	0.85 0.87 0.85	0.86 ± 0.01
2	1.05 1.03 1.03	1.04 ± 0.01	1.04 1.03 1.04	1.04 ± 0.00
3	0.84 0.86 0.88	0.86 ± 0.02	0.83 0.86 0.87	0.85 ± 0.02
4	0.88 0.86 0.92	0.89 ± 0.02	0.88 0.88 0.93	0.90 ± 0.02
5	0.62 0.63 0.70	0.65 ± 0.03	0.64 0.64 0.69	0.66 ± 0.02
6	0.70 0.69 0.67	0.69 ± 0.01	0.71 0.70 0.70	0.70 ± 0.00
7	0.82 0.84 0.82	0.83 ± 0.01	0.83 0.82 0.83	0.83 ± 0.00
8	0.81 0.78 0.82	0.80 ± 0.02	0.80 0.80 0.83	0.81 ± 0.01
9	0.64 0.64 0.63	0.64 ± 0.00	0.63 0.63 0.63	0.63 ± 0.00
10	0.78 0.77 0.78	0.78 ± 0.00	0.78 0.78 0.81	0.79 ± 0.01
11	0.47 0.48 0.50	0.48 ± 0.01	0.49 0.50 0.51	0.50 ± 0.01
12	0.84 0.81 0.81	0.82 ± 0.01	0.82 0.82 0.82	0.82 ± 0.00
13	1.37 1.38 1.41	1.39 ± 0.02	1.39 1.39 1.40	1.39 ± 0.00

DISCUSSION

Data listed in Table 1 demonstrates the complete equivalence of the EDTA method and the official sulfate method for the determination of the lead number of vanilla extracts. In fact, the EDTA method appears to be slightly more precise. The relative error of the EDTA determination is equal to, or less than, that of the sulfate method for each set of triplicate determinations. These data show that the EDTA titration can replace the official method.

The convenience of a volumetric method can lighten the burden that this time-consuming analysis now imposes on the vanilla chemist.

Acknowledgment

The technical assistance of Mr. B. Pearl is gratefully acknowledged.

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Notes and Letters

Development of the Poultry Products Inspection Act*

EVEN PRIOR to the 84th Congress when Hearings were first held on legislation of this nature, the Institute of American Poultry Industries went on record as favoring the development and adoption of sound mandatory inspection for wholesomeness programs for all poultry and poultry products. In the early days of this industry the Institute played a prominent part in helping this industry convert from the shipping of live poultry across the country to distant markets to the New York dressing type of operation. At that time this advance brought to the consumer, higher quality poultry. However, as we look at it today, this industry still had a long way to go.

Later, through still greater technology advances, the poultry industry moved from the New York dressed era to the fully-eviscerated ready-to-cook modern-type of operation. And today, it is estimated that more than 90% of our total output is fully eviscerated before it reaches the retail store, restaurant or other institutional user.

As this industry changed from New York dressed operations to the ready-to-cook procedure, poultry processors assumed a major responsibility and a task that was formerly undertaken in the consumer kitchen. We have vigorously promoted sound sanitation in the poultry processing plant. And today's modern operation is kitchen clean, with modern equipment and facilities that permit the maintenance of kitchen-clean operation.

These improvements in processing facilities and the application of new processing techniques along with tremendous strides made by those industries allied to the poultry industry have been instrumental in virtually doubling the per capita consumption of poultry during the past 20 years.

We in the poultry industry are on the threshold of a new and dynamic era. The production and marketing of wholesome foods of high-quality and the expanded consumption of such foods and their ready availability and acceptance by the consuming public are matters of basic interest to everyone affiliated with the poultry industry.

PUBLIC LAW 85-172

We believe that the Poultry Products Inspection Act (Public Law 85-172) passed by the 85th Congress represents one of the most constructive efforts of any Congress of the United States. Hearings were held in several Congresses and the Act that went into effect on May 1, 1958 on a voluntary basis, mandatory as of January 1, 1959, has already been extremely helpful to both the industry and the consuming public.

With the Poultry Products Inspection Act, the poultry industry is now in position to compete favorably with red meats. For many years the poultry industry had to pay for their inspection service but now red meat and poultry inspection are both on a comparable base with the Government paying the cost of inspection.

Most of you are familiar with the Act and the accompanying regulations. As you realize, many in the poultry industry hold strong convictions that administration of this program should remain with the Secretary of Agriculture and he in turn determine the appropriate governing agency. The Secretary of Agriculture has clearly recognized that it would have been unwise to overlook and ignore the fact that there are substantial differences between poultry and red meat animals; that their production, distribution and marketing channels are different; that the two commodities are in direct competition with one another.

It seems clear to many that an inspection program for poultry which would become a mere adjunct to a program which has been developed to meet the needs of large red meat animals would not be satisfactory. Poultry today is a very important segment of our agricultural economy. It is the third most important producer of cash farm income and accounts for about 11% of the gross income to agriculture. For these reasons and the fact that the Division of the Department of Agriculture which has done an outstanding job of developing and administering the voluntary poultry inspection program—the Poultry Division of the Department of Agriculture was given the responsibility of administering the Poultry Products Inspection Act.

ANTE MORTEM INSPECTION

The Law gives the Secretary of Agriculture full authority to require ante mortem inspection whenever he deems it essential to the production of wholesome poultry products. And the Secretary shall, where and to the extent considered by him necessary, cause to be made by inspectors, ante mortem inspection of poultry in any official establishment processing poultry or poultry products for commerce or in or for marketing in a designated city or area.

Actually, what this means is that ante mortem inspection will be performed where and to the extent necessary to assure wholesome product.

* Presented at the Nineteenth Annual Meeting of the Institute of Food Technologists, May 19, 1959, Philadelphia, Penna.

During the Congressional Hearings, it was stressed that the objective of any legislation should be to authorize and provide whatever type inspection is necessary to assure wholesomeness of product to consumers and to provide an effective workable and efficient program. We have felt the Secretary should be permitted to make maximum use of the developments in the arts and sciences; and to make improvements whenever and wherever possible. We have every confidence in the ability of the Secretary of Agriculture to carry out an inspection program which will fully assure the consumer of the wholesomeness of product. We have felt that assurance of wholesomeness to consumers can be better achieved by leaving to the Secretary of Agriculture the responsibilities for determining the type, character, and scope of inspection which is required to determine wholesomeness.

The horizons of sciences are ever changing and it seems to us that it would have been unwise to place any legislative limitation on the Secretary in developing better and less costly methods of inspection which research and expanding scientific knowledge may make available.

Another very important part of the Poultry Products Inspection Act is that section which would authorize the Secretary to cooperate with state agencies in carrying out the inspection programs on a coordinated and cooperative basis. Under this provision, it is possible for the Secretary and states having inspection programs to coordinate such programs and to make maximum use of both federal and state personnel and otherwise tend to strengthen both the state and federal programs. We feel this portion of the Law should result in the elimination of a variety of so-called trade barrier legislation that may now be in effect or be proposed at some later date.

A BRIEF PROGRESS REPORT

Here is a brief progress report concerning the Poultry Products Inspection Act and how industry has been able to move into this program.

In January of 1958, about a third of the USDA slaughter report represented poultry that was inspected under the voluntary program. In January of 1959 a little over 80% of the USDA slaughter report represented poultry that was processed under the Poultry Products Inspection Act. The biggest increase was in the broiler area for in 1958, about ¼ of the broiler industry was under the voluntary program and in January of 1959, 81½% of the broiler output was processed under the Poultry Products Inspection Act.

As of April 19, 1959, 472 plants were operating under the Poultry Products Inspection Act. This included 373 year-round full-time operations as well as those plants operating less than a 40-hour week. It also included the 68 seasonal full-time plants and 6 seasonal part-time plants. USDA has said that there are approximately 200 plants that are not currently operating under the program, but that they expect these plants will soon be handling product that goes across state lines and, therefore, will come under the authority of the Act.

At the present time there are several types of plants that are operating under exemptions and these include those producers who are exempt under the Act and exemptions for religious reasons and also those plants doing further processing. For those firms operating under exemptions, they are required to meet the Sanitary Standards set out in the regulations and applicable to their particular situation. They do not, at the present time, have inspectors in the plant, however, and are subject to spot check as provided by the Law.

Early in May, 1959, the Institute of American Poultry Industries testified before the Senate Agricultural Appropriations Committee urging that sufficient funds be provided by Congress to allow for full inspection as set out in the Poultry Products Inspection Act. The Institute's testimony was supported by 12 national, regional and state associations. In our testimony we went on to say . . .

"In an effort to provide for as orderly a transition to a system of mandatory inspection as possible, the Act specifically authorized plants which could qualify to submit to mandatory inspection before January 1, 1959, the date after which no product could be processed for commerce without Federal inspection. The Department started to administer the Act on this basis, but because of the limited appropriation and the consequent uncertainty as to the adequacy of the funds to carry out the inspection program for the entire fiscal year, this procedure was changed in the fall of 1958. Eligible plants were thereafter not permitted to come under the mandatory provisions of the Act until January 1, 1959. In addition, industry representatives were advised that funds would not even be sufficient to provide inspection on January 1, 1959, to all plants operating in interstate commerce. This resulted in much confusion and uncertainty and made the transition to compulsory inspection much more costly and difficult for the industry. Because of the lack of sufficient funds to carry out the Act in accordance with its terms, the Department adopted procedures which, in effect, nullified important features of the Act. The result is that inspection has not and is not now being provided as directed and the Act is not being fully and fairly carried out.

"To stretch the available funds sufficiently to provide inspection after January 1, 1959, to all eligible slaughtering and eviscerating operations, the Department adopted a so-called 'exempt' procedure for what it described as 'further processing' operations. (These operations include preparation of poultry products after the slaughtering and evisceration of the poultry.) This so-called exemption procedure in fact is not an exemption at all. It merely results in the denial of the use of an inspection legend on the product which is subject to regulation under the Act. These products which fall within the classification of 'further processed' products cannot be marketed in commerce unless they contain only poultry meat which is Federally inspected and unless they are prepared in plants which are constructed and operated in full compliance with the United States Department of Agriculture plant, facility and sanitary regulations. Notwithstanding this fact, the product is not permitted to bear an inspection legend showing the true fact that it is prepared of Federally inspected poultry meat and that it is prepared in a plant operating under Federal regulation. On the contrary, the product is required to be labeled in a manner to indicate that it is exempted from the provisions of the Poultry Products Inspection Act. This is contrary to the fact. It is misleading to the public. It is injurious to the poultry industry, in that such product is denied the benefit of a proper inspection legend and is required to carry a legend which is in fact derogatory since it implies that the consumer of such product will not have had the protection of inspection under the Poultry Products Inspection Act. This

is an intolerable situation which has been imposed because sufficient funds were not appropriated to permit 'continuous' inspection of the 'cooking retort' utilized in the preparation of poultry products in a form desired by consumers. This is a situation which should not be permitted to continue. It can be corrected in one of two ways: (1) By providing for the inspection of further processed products in substantially the same way as such inspection is now being carried out and permitting such products to be labeled in a manner to reflect the true facts; namely, that the product is prepared from federally inspected poultry meat in a plant complying with United States Department of Agriculture plant, facility and sanitary requirements, or (2) by appropriating sufficient funds to provide for the continuous inspection of the so-called 'further processing' operations."

One of the advantages that this industry sees from the Poultry Products Inspection Act will be the continual improving of product at the farm level so that a higher and higher percentage of only wholesome poultry will be entering processing plants. It is the feeling of many in industry that management practices will constantly improve with more complete sanitation programs at the farm level, thereby reducing the incidence of disease, and also reducing the number of down-grades.

INCREASED DEMAND FOR FOOD TECHNOLOGISTS SEEN

As a closing note, there is a general feeling within the trade, that our processing plants will be doing more and more in the field of consumer food items and as we move into this new technology, the demand for food technologists for the poultry industry will become even greater. To capitalize on these convenience food items will require trained technologists and we feel that there will be an even closer relationship between the poultry industry and the professional members with training in food technology.

The transition from the noninspected to the inspected operation has been far less troublesome than many anticipated. This smooth transition was made possible through the excellent cooperation of industry and Government alike. We in the poultry industry know that even greater progress will be made in the days ahead.

FRANK G. WOLLNEY
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Glossary of Some Terms Used in the Sensory (Panel) Evaluation of Foods and Beverages

THE FIRST OBJECTIVE of the Committee on Taste Testing (1958) of the Institute of Food Technologists was "To bring order out of chaos in this field where empiricism is rampant, definitions and terminology need to be established, methodology needs to be screened, evaluated and developed, and the results of such tests need to be interpreted in significant terms."

It became evident that, before much progress could be expected, some agreement on definitions of terms must be made. The committee therefore undertook to develop the following glossary of terms. The work was initiated by Dean Foster, who provided the committee with an initial list of 100 terms. All members of the committee contributed by suggesting additions or deletions of terms, and modifications of definitions. The final list was agreed upon by the entire committee, following considerable correspondence and oral discussions during the 1958 and 1959 conventions. The final list consists of only 85 terms. In making the final decisions for including and defining the terms, the committee was guided primarily by the extent to which the term is used specifically in sensory testing. If the term was used generally, and perfectly well understood, it was not included. Furthermore, if the term were used specifically in another discipline and merely applied to sensory testing without any special adaptation, then it would not be included. For this reason only a minimum of terms which are basically psychological or statistical in nature, were included.

It is hoped that two purposes will be achieved with the publication of this glossary; namely, that it will serve as:

1) A guide to students and investigators beginning work in this field.
2) An authoritative reference for use of these terms in order that different workers in the field will be "speaking the same language."

Although considerable thought has been devoted to this glossary, it should not be considered as definitive. In fact, comments, corrections, and additions will be welcomed by the taste testing committee. By such contributions, the glossary will become regarded eventually, we hope, as the glossary acceptable to the professional taste tester.

GLOSSARY

ABSOLUTE JUDGMENT. A psychophysical method in which no standard stimulus is used and which requires an estimate of the absolute intensity of a stimulus or a categorical judgment based on an observer's experience.

ABSOLUTE THRESHOLD. (See *threshold*).

ACCEPTANCE. 1) An experience, or feature of experience characterized by a positive (approaching a pleasant) attitude. 2) Actual utilization, (purchase, eating). May be measured by preference or liking for specific food item. The two are often highly correlated, but they are not the same.

ACRID. Sharp and harsh or bitterly pungent.

ACUITY. Ability to discern or perceive stimuli, sharpness or acuteness.

ADAPTATION. Loss of sensitivity to a given stimulus or as result of continuous exposure to that stimulus or a similar one.

AFTER-TASTE. The experience, which under certain conditions, follows the removal of a taste stimulus; it may be continuous with the primary experience or may follow as a different quality after a period of time, during which swallowing, saliva, dilution and other influences may have affected the stimulus substance.

AGEU'SIA. Lack or impairment of sensitivity to taste stimuli.

ANOSMIA. Lack or impairment of sensitivity to odor stimuli.

APPETITE. Lust or desire for anything, but more especially for food. (If hunger be regarded as the specific sensory experience localized in the region of the stomach and presumably aroused by slow rhythmical contractions of the stomach walls, then appetite for food can exist without hunger, and in civilized man ordinarily does occur, especially as habituated behavior dependent upon past experience with food.)

AROMA. A distinctive characteristic or suggestive of fragrance or odor.

ASTRINGENT. Quality perceived due to the complex of sensations caused by shrinking, drawing, or puckering of the skin surfaces of the mouth, accompanied by a driving of the blood from the tissues. Dry feeling in the mouth.

BASIC TASTES. (See *taste*).

BITTER. A quality of taste sensation, the taste of quinine sulphate being a typical example. Perceived by the circumvallate papillae at the back of the tongue.

BODY. The quality of a food or beverage, relating variously to its consistency, compactness of texture, fullness, or richness.

BURNING. As related to taste is used most often to describe the sensation of heat caused by inadequate stimulation, e.g., that of pepper, mustard, or other strong spices. It arises from the skin senses, including that of pain as well as those of temperature. When the adequate stimulus (hot material) is applied, the term *hot* is more likely to be used.

CHEWY. Tending to remain in the mouth without readily breaking up or dissolving. Requiring mastication.

COMPENSATION. The result of interaction of the components in a mixture of stimuli in which each component is perceived as less intense than each would be alone.

CONFIDENCE INTERVAL. (Statistical). A range of values which has a given probability (usually .95 or .99) of including the true value (parameter) of the quality attribute being rated.

CONTRAST. Juxtaposition of two different sensations which results in intensifying or emphasizing their contrary characteristics. It may be of two types: (a) simultaneous, or (b) successive.

CONTRAST EFFECT. Judgmental phenomenon which appears in evaluating food samples of different preference (or quality) levels where the presentation of one sample tends to make a following sample of the opposite quality rate either higher or lower than they would had they been rated independently.

COOLING. A physical sensation in the mouth resulting from the presence of a cold liquid or solid. Also result of chemical action [illegible] sensed by the skin.

DIFFERENCE TEST. A comparison or test of quality variations without indication of preference.

DISCRIMINATION. 1) Perception or difference between two or more objects in respect to certain characteristics; 2) a differential response to two stimuli which differ quantitatively or qualitatively.

DUAL STANDARD/METHOD OF DIFFERENCE TESTING. Two samples are identified and presented first as knowns, then they are given again as unknowns for the observer to identify.

DUO-TRIO/METHOD OF DIFFERENCE TESTING. One of a pair of samples is identified and presented first. Then the observer receives two more samples as unknowns in random order. The time interval can be varied as desired. The observer's task is to pick the *different* sample.

ENHANCEMENT. (See *contrast*).

EXPERT. Generally, an individual acknowledged to be experienced and skillful in a special practice; in the food and beverage field, a specialist who usually confines his diagnostic judgments to a specific product under specific conditions, even though others attribute to him special powers of discrimination, sensitivity and perspicacity applying to other products and conditions.

FATIGUE. Condition of organs or organisms which have undergone excessive activity with resulting loss of power or capacity to respond to stimulation. (See *adaptation*).

FLAVOR. 1) A mingled but unitary experience which includes sensations of taste, smell and pressure, and often other cutaneous sensations such as warmth, cold, or mild pain. 2) An attribute of foods, beverages and seasonings resulting from the stimulation of those senses which are grouped together at the entrance to the alimentary and respiratory tracts—especially odor and taste.

FLAVORING. Any substance, such as an essence or extract, employed to give a particular flavor.

THE FLAVOR PROFILE TECHNIQUE. A method of qualitative description analysis of aroma and flavor. The method makes it possible to indicate degrees of difference between two samples on the basis of individual character notes, and the degree of blending, and the overall impression of the product.

FORCED JUDGMENT. A reaction required by an experiment in which "don't know," or other undeterminate answers are not permitted.

FRAGRANT. A pleasing olfactory quality; odors which are distinctly pleasant smelling.

GRITTY. A hard, stone-like sensation, usually caused by the presence of sand particles or stone cells. Not a sensation, but a judgment based on complex perception.

GUST. A unit of gustatory intensity relating to the threshold of a given substance.

GUSTATION. A sense (taste) whose receptors lie in the mucous membrane covering the tongue and whose stimuli consist of certain soluble chemicals; e.g., salts, acids, sugars, etc.

HAPTIC. Pertaining to the skin or to the sense of touch in its broadest sense.

HEDONIC. Pertaining to feeling or feeling tone; hedonic tone is the pleasurable or unpleasurable accompaniment or characteristics of conscious experiences.

INADEQUATE STIMULUS. When a reaction is obtained by the application of energy which is not "normal" to the sense system involved (such as an electrical current applied to the tongue producing a taste), the non-normal stimulus is termed *inadequate*.

JUDGE. (See *subject, observer*). One who participates in a test by providing data which generally are verbal reports of his experience. The term connotes that the person has some special qualification; also, it connotes a situation where primary attention is directed toward the samples.

MASKING. In taste, odor, or flavor applications, it is a component quality within a mixture which dominates or overrides another quality or other qualities present, thus changing the quality of the perceived resultant without benefit of chemical interaction of the components themselves.

MATCHING. The process of equating or relating, pair by pair, for experimental purposes usually to determine the degree of similarity between a standard and an unknown, or two unknowns.

MEALY. A quality of mouth feel denoting a starch-like sensation. Friable.

MEDICINAL. An olfactory sensation denoting a usually unpleasant medicine-like taste or smell.

MULTIPLE COMPARISON. An unlimited number (usually more than three) of samples is presented to the observer simultaneously in random arrangement or in accordance with a predetermined statistical design. Significance of results is usually calculated by the variance method, or a rapid approximation thereof.

MOUTHFEEL. The mingled experience deriving from the sensations of the skin in the mouth after ingestion of a food or beverage. It relates to density, viscosity, surface tension and other physical properties of the material being sampled.

OBJECTIVE. 1) Capable of being recorded by physical instruments or as a consequence of a repeatable operation. 2) Not dependent upon the observations and reports of an individual and thus verifiable by others.

OBSERVER. (See *subject, judge*). One who participates in test by providing data which generally are verbal reports of his own experience. This term, in contrast to *judge*, connotes a situation where primary attention is directed toward the person's response.

ODOR. Sensation due to stimulation of the olfactory receptors in the nasal cavity by gaseous material.

ODORANT. A chemical substance which stimulates the olfactory receptors.

OLFACTOMETER. An instrument for controlled presentation of odor stimuli, used for measuring thresholds and other quantitative values.

ORGANOLEPTIC. 1) Affecting or making an impression upon an organ or the whole organism; 2) capable of receiving an impression; 3) sometimes used as a synonym for *sensory* when referring to examination by taste and smell (obsolescent).

PAIRED COMPARISON/METHOD OF. A psychometric or psychophysical method in which stimuli (samples) are presented in pairs for comparison on the basis of some defined criterion, such as preference, intensity, degree of a defined quality, etc. The traditional form requires that each sample in a series be compared with every other member in the series.

PAIRED PREFERENCE. Paired comparison method using the preference criterion.

PALATABLE. Agreeable to the "taste," savory; hence, acceptable or pleasing.

PANEL. A group of people (observers, subjects, judges), comprising a test population which has been specially selected or designated in some manner, e.g., they may be trained, or have special knowledge or skills, or may merely be available and predesignated.

PREFERENCE. 1) Expression of higher degree of liking. 2) Choice of one object relative to others. 3) Psychological continuum of affectivity (pleasantness—unpleasantness) on which such choices are based. This continuum is also referred to as that of degree of liking or disliking.

PRIMARY QUALITIES. Within a specific sense, those qualities which are considered basic and from which all other qualities can be compounded. There is general belief that salt, sweet, bitter and sour are the four primary taste qualities.

PSYCHOMETRICS. The quantitative or mathematical aspects of psychological procedure. It includes determination of the mathematical relation between quantitatively varied stimuli and the frequencies of a given judgment upon them usually by one of the several psychophysical methods.

PSYCHOPHYSICAL METHODS. A group of specific procedures used in psychophysical investigation. Fechner adopted three: the methods of limits, average error and constant stimuli. Guilford lists others and a number of variations of each procedure.

PSYCHOPHYSICS. The study of the quantitative relations between a stimulus and the ensuing sensation or other experiences.

PURE ODORS OR TRUE ODORS. Olfactory experience unaffected by the action of other senses of the skin and mouth, especially the trigeminal and taste receptors.

QUALITY (1-PSYCHOL). 1) An aspect, attribute, characteristic, or fundamental dimension of experience, which involves variation in kind rather than in degree. 2) The composite of those characteristics that differentiate among individual units of a product and have significance in determining the degree of acceptability of that unit by the user.

RANCID. Having a rank odor or taste, as that of old oil.

RANK ORDER. (Ranking). A psychometric method that may be used in multiple comparisons where the subject considers all of the samples on a series at the same time and is required to rank them in order on some designated dimension, such as preference, intensity, quality, etc.

RATING SCALE. (See *absolute judgment*). A method for securing and recording a judgment concerning the degree to which a stimulus material possesses a specified attribute, usually by placing a mark at an appropriate position between the two extremes of a line that represents the possible range of degrees of that attribute.

REFERENCE SAMPLE. (See *standard*). In a multisample test, the sample designated as the one to which all others are to be compared.

SALTY (SALINE). A quality of taste sensation of which the taste of sodium chloride is the typical example.

SCORE. 1) (n.) A value assigned to a specific response made to a test item; 2) (v.) To score a food is to rate its properties on a scale or according to some numerically defined set of criteria.

SENSORY. Pertaining to the action of the sense organs.

SHARP. Characterizing an intense or painful, well localized reaction to a substance being eaten or smelled; e.g., various acids and alcohols.

SIGNIFICANCE. *(Statistical)*. Referring to the probability that differences (among samples or treatments) are real, and not due to chance variation. A difference which has a .05 probability of occurring by chance alone is usually considered a significant difference and a highly significant difference, one which could occur by chance with .01 probability.

SINGLE STIMULI/METHOD OF. Any phychophysical or psychometric method in which a judgment follows the presentation of one stimulus only.

SOUR. A quality of taste sensation of which the taste of acid is the typical example.

STIMULUS. A change of energy in the environment which affects a sense organ.

SUBJECT. (See *judge, observer*). One who participates in a test by providing data. This is the generic term which is appropriate wherever any of the related terms may be used. Thus, it includes not only those who provide subjective or verbal data, but also those who respond in any other way. Subject, Judge, and Observer are terms whose usage is supported by custom and, as such, are distinguished from such casual words as "tester," "taster," "panelist," "sniffer," etc.

SUBJECTIVE. Pertaining to individual experience which can be observed and reported on only by the person involved, i.e., mental phenomena that usually are verbally reported.

SUBLIMINAL. Below the threshold (applied to stimuli which are not sufficiently intense to arose definite sensations, but which, nevertheless, have some effect upon the responses of the individual).

SWEET. A quality of taste sensation of which the taste of sucrose is the typical example.

TACTUAL. Pertaining to the sense of touch.

TASTE. (See *gustation*). One of the senses, the receptors for which are located in the mouth and are activated by a large variety of different compounds in solution. Most investigators usually limit gustatory qualities to four: saline, sweet, sour, bitter. Distinguish from Flavor, the experience to which taste contributes.

TEXTURE. (See *mouthfeel*). Those properties of a foodstuff, apprehended by the eyes and by the skin and muscle senses in the mouth, including the roughness, smoothness, graininess, etc.

THRESHOLD OR LIMEN. A statistically determined point on the stimulus scale, at which occurs a transition in a series of sensations or judgments. Thresholds are of three kinds: 1) The threshold of sensation, *stimulus threshold*, or *absolute threshold*, often designed as RL, which is that magnitude of stimulus at which a transition occurs from no sensation to sensation; 2) The *difference threshold*, the least amount of change of a given stimulus necessary to produce a noticeable change in sensation. It is often designated as the DL and the interval or unit as the j.n.d. (just noticeable difference); 3) The *terminal threshold* which is that magnitude of a stimulus above which there is no increase in the perceived intensity of the appropriate quality for the stimulus (above this point pain often occurs).

TRIANGLE/METHOD OF DIFFERENCE TESTING. The test unit consists of three samples. All three are coded so that they are unknown, but the observer is told that two are alike and one is different. It is his task to pick the *different* sample.

Submitted by AMIHUD KRAMER, Chairman, Taste Testing and Consumer Preference Committee (IFT) 1958.

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Author Index, *Food Technology*, Volume 13, 1959

Author	*Page*
Allison, James B.	597
Ambrose, Mary E.	249
Amerine, M. A.	170
Amla, B. L.	485
Ammerman, Gale	183
Anderson, A. W.	465
Antonevich, J. N.	109
Atkinson, F. E.	673, 676
Ayres, John C.	294, 420, 512, 520, 578
Bachmann, H. J.	529
Bailey, C. B.	170
Bailey, Glen F.	394
Baldwin, R. R.	624
Ball, C. Olin	193
Barber, F. W.	378
Bard, G.	217
Batzer, O. F.	501
Bedrosian, Karakian	722
Beerh, Om Parkash	414
Benarde, Melvin A.	80
Bender, Maurice	249
Berman, M. D.	365
Beyer, William	300
Bhatia, B. S.	349, 553
Binder, R. J.	213
Birdsall, John	300
Blaisdell, John L.	659
Blakley, T. S.	610
Boggs, Mildred M.	136, 258
Bohart, G. S.	136
Bolaffi, Andre	624
Bowen, J. F.	673, 676
Bramblett, Vianna D.	707
Bratzler, L. J.	236
Brekke, J. E.	213, 341
Brice, B. A.	30
Bring, S. V.	313
Brody, Aaron L.	103, 119
Brown, A. H.	232
Buck, Paul	300
Burroughs, J. D.	567
Calvin, Lyle D.	469
Campbell, A. A.	25, 477
Campbell, C. L.	398, 405
Campbell, L. Leon	462
Carlin, Agnes Frances	520, 557
Carroll, Floyd	337
Chang, Lucy	501
Chaplin, C. E.	587
Chastain, Marian Faulkner	527
Checchi, Arthur A.	604
Chichester, C. O.	36, 337, 684
Circle, S. J.	307
Clark, Berton S.	289
Clarke, B. W.	62
Claypool, L. L.	208, 727
Clifcorn, L. E.	176
Coffin, William J.	578
Coit, J. E.	213
Conley, W.	217
Connell, J. C.	228
Considine, William J.	730
Cotterill, Owen J.	476, 557
Cover, Sylvia	655
Cowell, N. D.	425
Crowe, P. F.	286
Curl, A. Laurence	394
Davis, L. D.	208
Davison, Sol	119
de Fremery, D.	25
Delaney, Isabelle	476
Desrosier, N. W.	183
Dietrich, W. C.	136, 258
Dimler, R. J.	663
Dodge, J. W.	81
Doty, D. M.	501
Downes, N. J.	113
Draudt, H. N.	707
Dryden, E. C.	84
Duggan, D. E.	465
Duncan, D. T.	159
Dunsing, Marilyn	332, 451, 516
Eindhoven, Jan	379
Elliker, P. R.	465
Ellis, Cordelia	533
Esau, Paul	346
Escanilla, Ofelia I.	520
Esselen, W. B.	593
Estelle, Marlene	489
Evans, H. L.	425
Evans, Ralph L.	128
Ezell, George H.	9
Fabri, Ilona	318
Fagerson, I. S.	352, 358
Fanelli, Mary Jeanne	294
Fatta, Louis D.	509
Fazzina, T. L.	224
Felsenthal, Peter	119
Ferrel, R. E.	473
Firman, M. C.	529
Fixari, F.	217
Fletcher, Lorraine R.	221
Folinazzo, John F.	179
Fox, J. B. Jr.	501
Franceschini, R.	358
Francis, F. J.	352, 358, 485
Frank, S. S.	307
Gaddis, A. M.	286
Geminder, J. J.	459
Gold, Harvey	281
Goldblith, S. A.	94, 272
Goresline, Harry E.	241
Graf, Robert L.	492, 719
Graikoski, J. T.	650
Greenberg, Richard A.	509
Griffiths, Francis P.	430
Gross, Gerald B.	621
Guadagni, D. G.	14
Gunderson, Frank L.	541
Guse, Dennis G.	474
Hall, Barbara A.	699
Hanamoto, Max	99
Hand, D. B.	270
Hanson, Helen L.	20, 221, 477
Hard, Margaret M.	711
Hardy, Paul W.	571
Hartsell, Stanley E.	474
Haugh, Raymond R.	241
Hays, G. L.	567
Heiligman, Fred	159
Heiss, R.	433
Hewitt, Eric J.	128
Heyrich, F. J.	529
Hicks, E. W.	425
Hills, Claude H.	84, 251
Hiner, Richard L.	155
Hoff, J. E.	94
Homeyer, Paul G.	557
Hooker, W. J.	159
Hoover, M. W.	448
Hoover, William J.	592
Hopper, P. F.	529
Hostetler, Robert L.	707
Hotchner, S. J.	228
Ignall, H. R.	276
Ihde, Aaron	240
Irvin, Lanell	655
Johnson, Joseph M.	186, 385
Jones, A. H.	239
Kuhlenberg, O. J.	640
Kamstra, L. D.	652
Kan, B.	346
Kaplan, Arthur M.	244
Karel, M.	69
Kaufman, Vera F.	561
Kehoe, D.	1
Kempe, L. L.	75, 650
Kenyon, L. J.	441
Kester, E. B.	473
King, Charles Glen	66
Kiratsous, A.	485
Klis, John B.	124
Klose, A. A.	20, 25, 477
Konigsbacher, Kurt S.	128
Kramer, Amihud	62, 733
Krishnamurthy, G. V.	553
Kropf, Donald H.	492, 719
Kuhn, Gerald	183
Kutz, Natalia	318
LaBelle, R. L.	270
La Fuente, B.	272
Lal, Girdhari	553
Lang, Agnes	318
Larson, R. A.	378
Lehrer, W. P. Jr.	313
Leniger, H. A.	347
Leonard, S. J.	253, 418, 444, 727
Lepkovsky, Samuel	421
Levin, Ezra	132
Lucciardello, J. J.	398, 405
Lilyblade, A. L.	204
Lime, Bruce J.	430
Lineweaver, Hans	20, 221
Lindquist, F. E.	136
Little, Angela C.	684
Livingston, Gideon E.	303, 352, 358, 525
Lopez, Anthony	186, 385
Lowry, J. R.	624
Luh, B. S.	253, 418, 444, 645, 727
Lukes, Thomas M.	391
MacGregor, D. R.	673, 676
Mackinney, Gordon	684
Martin, Ruth	204
Mason, R. Hal	704
Mattil, K. F.	46
McDonald, Joan G.	699
McGill, J. N.	75
McKirahan, R. D.	228
McLean, R. A.	286
Mellor, J. D.	425
Meyer, R. C.	146
Mezzino, J. F.	624
Middleton, E.	597
Morgan, A. I. Jr.	232, 691

Author	Page
Morris, H. J.	136
Morse, R. E.	441
Moser, Roy E.	385
Moyer, J. C.	92, 270, 581
Mrak, Emil M.	253
Nagel, Charles W.	153
Naumann, H. D.	640
Nelson, A. I.	75, 410, 722
Neumann, H. J.	136, 258
Ng, Henry	153
Nicholas, R. C.	58
Nickerson, J. T. R.	224, 398, 405
Nickerson, T. A.	107
Notter, G. K.	113, 341, 574
Nutting, G. C.	30
Nutting, L. A.	378
Nutting, Marvel-Dare	136, 258
O'Brien, R. T.	462
Ohgren, Carl W.	374
Olson, R. L.	136, 258
Orbanyi, Tekla	318
Ordal, Z. John	124
Oser, Bernard L.	607
Ough, C. S.	170
Pallesen, H. R.	92, 581
Pangborn, Rose Marie	107, 418, 444, 489, 557
Pauls, Rubena H.	711
Pearson, A. M.	501
Pence, J. W.	99
Peryam, David R.	379
Peters, Fredus N. Jr.	550
Peterson, D. W.	204
Pih, Katherine	501
Pillion, Elizabeth	244
Platt, William T.	155
Pollak, G. A.	276
Pool, M. F.	20, 25, 477
Pope, D. T.	448
Pratt, George B.	149
Proctor, Bernard E.	69, 94, 119, 224, 266, 272, 383, 398, 405, 679
Ransford, J. R.	270
Reeve, R. M.	561, 574
Rickard, C. A.	313
Rieman, G. H.	456
Robinson, James F.	251
Robinson, W. B.	270
Roby, Mabry T.	327
Rodriguez, J. G.	587
Rogers, Morris R.	244
Rohrer, D. E.	645
Rongey, E. H.	640
Ronsivalli, L.	224
Ross, Edward	711
Sabry, Zakaria I.	303
Saffle, R. L.	236, 652
Salwin, Harold	594, 715
Sanders, J. H.	41
Saravacos, G. D.	94
Sather, Lois A.	469
Scharschmidt, R. K.	456
Schenck, Anna May	262
Schenck, Roy U.	667
Schoman, C. M. Jr.	615
Segall, Stanley	266, 383, 679
Senti, F. R.	663
Shallenberger, R. S.	92, 581
Shepherd, Allan D.	539
Siddappa, G. S.	349, 414
Silliker, John H.	509
Simon, Morris	30, 327
Simone, Marion	36, 204, 337, 444, 727
Simpson, Kenneth L.	153
Slawson, Vida	715
Sliwinski, R. A.	501
Smith, A. M.	30
Smith, G. S.	232
Smith, R. K.	224
Smithies, W. R.	610
Sniff, Esther E.	462
Sperring, Doris D.	155
Spoerlein, T.	597
Spooner, Mildred E.	501
Stadelman, W. J.	81, 689
Stamler, Jeremiah (M.D.)	50
Stanley, W. L.	96
Stare, Fredrick J. (M.D.)	33
Steinberg, M. P.	75, 410, 722
Stephens, Lois Carter	527
Sterling, Clarence	629
Stern, J.	224
Stewart, George F.	153
Suggs, F. G.	286
Swift, C. E.	365
Szabo, Gabriella	318
Taimuty, Samuel I.	704
Tan, Chee Teck	303, 525
Tarladgis, Basil G.	635
Tarver, Mae-Goodwin	262, 699
Taylor, D. H.	113, 341
Tichenor, D. A.	587
Titus, May C.	323
Tomiyama, Tetuo	370
Tompkins, Mardell D.	149
Trantanella, Shirley R.	165
Twigg, B. A.	62
Vail, Gladys E.	707
Van Arsdel, W. B.	14
Van Duyne, Frances O.	323
Vannier, S. H.	96
Vas, K.	318
Vaughn, Reese H.	153, 489
Vetter, J. L.	410
Waldt, L. M.	1
Walker, Homer W.	578
Wannemacher, R. W. Jr.	597
Warner, R. C.	567
Wasserman, Theodore	232, 691
Watts, Betty M.	635
Weckel, K. G.	281, 300, 456, 547
Wegener, John B.	4
Weiser, H. H.	146
Welch, John L.	179
Wells, F. E.	584
Wertheim, J. H.	94
West, Leeta C.	323
Wheaton, E.	571
Whitaker, John R.	86
Wiant, D. E.	58
Wiele, M. B.	20
Wiley, Robert G.	694
Williams, K. T.	213
Winter, A. R.	146
Winter, J. D.	165
Wise, R. G.	689
Wiseman, G.	69
Wishnetsky, T.	352
Wistreich, H. E.	441
Witter, Lloyd D.	124
Wollney, Frank G.	731
Wong, Francis F.	561
Wood, Charles B.	186, 385
Wood Mary B.	544
Woodroof, J. G.	533
Wuhrmann, J. J.	33
Yone, Yasuo	370
York, George K. II	489
Younathan, Margaret Tims	635
Zachringer, M. V.	313
Zahradnik, John W.	659

Subject Index, Volume 13, 1959

Subject	Page
Acidity and sweetness adjustment in canned Bartlett pears	727
Aeronizing, influence of, on organisms causing spoilage in commercially processed fryers	153
Adulterants in tomato ketchup, detection of, by spectrophotometric method	414
Aluminum chloride precipitation method for preparing pectin from papaya	553
Antibiotics, Aeronize chlortetracycline, comparison of methods of applying to beef	529
Antibiotics, use of, to control exudation in french fry, prepeeled potatoes	485
Antifungal antibiotic A-5283, A-5288, myprozine, pimaricin	420
Antifungal antibiotics, effect on food spoilage fungi	124
Antioxidants in irradiated cooked pork	635
Apple cider, taste thresholds for sodium benzoate and sodium sorbate in	84
Apple slices, processing of, relationship of apple grade and size	385
Apple slices, trimming time and yield factors in processing of	186
Apple tissue, effect of borates and other inhibitors on enzymatic browning	722

Subject	Page
Application of two-sample difference test in screening flavor panels, method for	699
Apricots, canned, drained weight of	253
Army rations, dehydrated, compatibility of, with chlorinated and iodine-treated waters	244
Atherosclerosis, cholesterol, dietary fats, experimental studies on	50
Atomic submarines, food engineering for	615
Azeotropic solvent processing to produce fish flour, fish meal	132
Bacterial count, palatability, thiamine content of freezer stored ham loaf, Italian rice, and chicken	323
Bacteriological flora of frozen coconut	378
Bartlett pears, canned, sweetness and acidity adjustment in	727
Beans, frozen, effect of blanching conditions on color stability of	258
Beef carcasses, effect of grade, weight, class on chemical and sensory evaluations of quality	719
Beef, comparison of methods for applying Aeronize chlortetracycline to	529
Beef, consumer preferences for, in relation to different breeds, carcass and quality grades	516
Beef, effect of low temperature, long time cooking, on qualities of	707
Beef from animals of different age, consumer household panel preferences for	332
Beef from Brahman-Hereford crossbreds and from Herefords, preference for	451
Beef, fresh, use of chlortetracycline in coating materials or film to enhance color, storage life of	512
Beef from 18- and 30-month steers, differences in eating quality of	337
Beef muscle, tenderness in, measured by pressure	155
Beef muscles, collagen content of, effect of dry heat method of cooking on	655
Beef quality, interrelationships of subjective, chemical, and sensory evaluations	492
Beef, raw, radiation induced chemical changes in	501
Beef, water retention of, factors affecting	365
Beet puree, pyrrolidonecarboxylic acid formation during production of	92
Bitterness in preserved orange juice	349
Blanching and drying rate of peas, interaction between	581
Boysenberries for frozen pies, composition of, quality evaluation of	645
Breast muscles, poultry, tenderness of, in relation to post mortem aging	81
Broccoli, effect of gamma irradiation on color of	352, 358
Broilers, frozen, prevention of darkening in	533
Browning, enzymatic, in apple tissue, effect of borates	722
Cakes, freezing and defrosting of	99
California wines, color value of	170
Candies, hard, stored, prevention of graining and stickiness in	433
Canned Bartlett pears, sweetness and acidity adjustment in	727
Canned foods, use of subtilin and nisin to lower heat process requirements of	462
Canned fruit, drained weight behavior in, role of the cell wall	629
Canning quality of cling peaches	208
Carob varieties and composition	213
Carotenoid pigment changes in Valencia orange powder during preparation and storage	394
Carrots, effect of gamma irradiation on color of	352
Cathode rays, gamma rays, ultraviolet light, effect of, on radiation preservation of milk and milk products	272
Cell wall, role of, in drained weight behavior in canned fruit	629
Central station supervisory control for food processing	374
Chemical and sensory evaluation of beef quality, effect of grade, weight, class of carcass on	719
Chemistry of starch, food technology aspects	1
Cherries, Montmorency, pitted, sirup-packed, consumer preference for sweetness of	300
Chicken, cut-up, aproximation of surface areas and use in microbiological analysis	241
Chicken, frozen fried, effect of pretreatment and type of packaging material on quality of	557
Chicken, frozen, fried, time-temperature tolerance of	221
Chicken, tenderness of, influence of processing on	25
Chicken, ready-to-cook, cut-up, frozen, time-temperature tolerance of	477
Chickens, whole eviscerated, gamma ray pasteurization of	75
Chicken meat, irradiated, storage characteristics of	398
Chicken muscle, factors affecting flavor and toughness of	204
Chicken pies, microflora of, methods of detection, effects of freezing	294
Chlorinated and iodine-treated waters, compatibility with dehydrated Army rations	244
Chlorine dioxide for cannery sanitation and water conservation	179
Chlortetracycline in ice, fluorometric determination of	370
Cholesterol, atherosclerosis, dietary fats, experimental studies on	50
Citral content of lemon oil, effect of processing on	96
Citrus concentrate, frozen, flavor evaluation methods for, compared	149
Cling peaches, effect of cold and modified atmosphere storage on canning quality of	208
Clinical, epidemiological observations on fats in the diet	33
Clostridium botulinum, inoculated into perishable cured meat, influence of sodium chloride on	509
Coconut, frozen, bacteriology of	378
Coffee brew, components of, influence of high temperature holding on	266, 679
Coffee brew, high temperature holding, volatile reducing substances of components of	383
Coffee, color of, effect of roasting conditions on flavor development for a given color	684
Coffee, roasting characteristics of green coffee beans, role of initial moisture level on	684
Collagen content of two beef muscles, effect of dry heat cooking on	655
Color measure, uniformity of, in green beans	711
Color stability of frozen green beans, effect of blanching conditions on	258
Color standards for white potato granules	30
Color values of California wines	170
Colorimetry of strawberry preserves	303
Concord grape juice, concentrated, relation of naturally occurring tartaric acid to certain physical constants of	4
Conduction errors in thermocouples used for heat penetration measurements	425
Consumer household panel, visual and eating preferences of, for beef from Brahman-Hereford crossbred and Herefords	451
Consumers, what they expect from food standards	544
Continuous high vacuum drying techniques	217
Control charts, extreme value, use of, in packaging industry	262
Cooking, long time, low temperature, effect of, on beef qualities	707
Corn, high-amylose, properties and prospects	663
Corn, whole kernel, peroxidase inactivation of H T S T processing of	410
Cured hams, factors influencing color of	640
Cured meat, perishable, inoculated with *Cl. botulinum*, influence of sodium chloride on toxin production, organoleptic breakdown	509
Curing of ham, a study of sodium chloride accumulation	441
Curing temperature, effects of, on gas permeability, moisture equilibration of stored peanuts	667
Darkening, prevention of, in frozen broilers	533
Defrosting of frozen foods, ultrasonic	109
Dehydrated foods, minimum moisture contents for	594
Dehydrated foods, moisture transfer in combinations of	715

Subject	*Page*
Dehydrated potato products, microscopic method for counting ruptured cells in	574
Dehydration of foodstuffs, design of freeze-drying equipment for	610
2, 6, Dichlorobenzenoneindophenol solutions	343
Dietary fat, observations on	33, 46, 50, 66
Dietary protein requirements and problems of supplementation	597
Dill pickle quality, effect of sugar, storage time and temperature	489
Drained weight of canned apricots	253
Drying rate of peas, interaction between blanching and	581
Eating quality factors of beef from 18- and 30-month steers, differences in	337
Economic impact, potential, of food irradiation	704
Edible protective coatings for extending shelf life of poultry	146
Environmental and processing factors, effect of, on the citral content of lemon oil	93
Enzymes applied to enhance flavor, panel studies on food thus treated	128
Fatness, effect of, on processing and palatability characteristics of pork carcasses	236
Fats in food	33, 41, 46, 50, 66
Fats make good foods, the where and why of the margins	66
Federal Definition and Standards of Identity for foods	550
Ficin, milk clotting activity of	86
Fish flour, fish meal by azeotropic solvent processing	132
Fish, smoked, use of potassium and sodium sorbate to extend shelf-life of	459
Flash evaporators, commercial scale evaporation of tomato products in	232
Flavor and toughness of chicken muscle, factors affecting	204
Flavor, coffee, effect of roasting conditions on, in relation to a given color	684
Flavor enzymes, panel studies on processed foods employing	128
Flavor evaluation methods for frozen citrus concentrate, comparison of	149
Flavor panel members, method for screening	699
Flavors in meat, evaluation of, by use of aqueous extracts	286
Fluidized bed finish drying, improving potato granules quality by	327
Fluorometric determination of chlortetracycline in ice	370
Food Additives Amendment of 1958	592, 604
Food Additives Amendment of 1958, pressing problems under	607
Food Additives (symposium)	603
Food combinations, measuring preferences for	379
Food engineering for atomic submarines	615
Food packaging films, factors affecting water-vapor transfer through	69
Food spoilage fungi, effect of antifungal antibiotics on	124
Food Standards (symposium)	541
Food Standards, what consumers expect from	544
Fouling of evaporator tubes by tomato	691
Freestone peaches, effect of sucrose, citric acid, corn syrup on acceptance	444
Freeze-dried soup mixes, storage stability of	36
Freeze-drying equipment for dehydrating foodstuffs	610
Freezing and defrosting of cakes	99
Frozen fried chicken, effect of pretreatment and type of packaging material on quality of	557
Frozen fried chicken, time-temperature tolerance of	221
Frozen foods, time-temperature tolerance of, temperature histories vs. quality of	14
Frozen green snap beans in retail packages, time-temperature tolerance of	136
Fruit products preserved by sodium and mild heat	251
Fryers, commercially processed, influence of aeronizing on spoilage organisms on	153
Gases, effect of various, on pressure packaged foods	567
Gelatin, effect of radiation on	624
Glossary of terms used in sensory panel evaluations of foods, beverages	733
Grade, size of apple, related to apple value in processing apple slices	385
Grade standards in quality control of fishery products	249
Grades of raw tomatoes, procedures for determining	62
Grades, beef, consumer preferences for	516
Grain-infesting pests, radiation of, death curves, survival values for the various metamorphic forms	58
Grapefruit juice, viscosity of	9
Grapefruit products, debittering of, with naringinase	430
Green beans, effect of gamma radiation on color of	352, 358
Green beans, uniformity of color measure in	711
Ground pork and beef, effect of packaging on	165
Haddock, whole, eviscerated, rapid determination of quality of	224
Ham, curing of, sodium chloride accumulation	441
Hams, cured, uniformity and stability of color of	640
Heat, conduction, errors in thermocouples	425
Heat exchanger, scraped surface, longitudinal temperature distribution in	659
High-amylose corn	663
High temperature holding, effect on coffee brew components	266
Horticulture, undergraduate teaching in	590
Ice cream, sugar in, consumer preferences for	107
Identity, standards of	541, 544, 547, 550
Industry view of Federal Definitions and Standards of Identity	550
Inert gas and flexible packaging materials, use of, to increase shelf life of food products	621
Inhibitors, effect of borates and other, on enzymatic browning of apple tissues	722
Ionizing radiation, effect on gelatin and various radioprotective agents	624
Irradiated cooked pork, antioxidants in	635
Irradiation, food, potential economic impact of	704
Italian rice, chicken, ham loaf, effect of freezer storage, variations in preparation on bacterial content, thiamine content, and palatability of	323
Lactobacillus acidophilus, a frozen concentrate of, for preparing acidophilus milk	465
Lemon oil, effects of environment, processing on citral content of	96
Lysozyme, effect on bacterial spores	474
Maine sardine production control, application of food technology to	289
Meat, chlortetracycline residues in, effect of storage and cooking	520
Meat flavors, evaluation of, by use of aqueous extracts	286
Meat, prepackaged, factors affecting quality of	193
Mercaptans, components of coffee brew, effect of high temperature holding on	679
Metallic iron, effect of, on spoilage of canned pork luncheon meat	650
Method for screening flavor panel members	699
Microbiological analysis, approximation of surface areas of cut-up chicken for use in	241
Microbiological aspects of pressure packaged foods	567, 571
Microflora of chicken pies, methods of detection	294
Microscopic structure and reconstitution of vacuum-dried tomato powders	561
Microwave heating to determine total solids in liquid egg products	476
Military foods, an appraisal of new processing methods for	176
Milk, acidophilus, frozen concentrate of *L. acidophilus* used in preparing	465

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740A

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740B

Subject	*Page*
Milk-clotting activity of ficin	86
Milk, milk products, radiation preservation of	94
Minimum moisture contents for dehydrated foods	594
Moisture equilibration of stored peanuts	667
Moisture transfer in combinations of dehydrated foods	715
Muscles, beef, variation of, in relation to water retention	365
Naringinase, debittering of grapefruit products with	430
Nutritional progress, potential pathways in	421
Onions, pinking of, during dehydration	391
Orange juice powder, storage stability of	113
Orange juice, preserved, bitterness in	349
Orange juice, viscosity of	9
Orange powder, Valencia, changes in carotenoid pigments of, during preparation and storage	394
Packaging, effect of, on palatability and weight loss of ground beef and pork	165
Packaging, flexible, and inert gas, use of, to increase shelf life of food products	621
Packaging films, food, factors affecting water-vapor transfer through	69
Packaging material, effect of, on frozen fried chicken	557
Packaging, microbiological aspects of pressure packaged foods	567, 571
Packaging, use of extreme value control charts in	262
Panels, student preference vs. household consumer	469
Papayas, preparation of pectin from	553
Peanuts, stored, effect of curing temperature on gas permeability and moisture equilibration of	667
Pea tenderometer, strain gage, the instrument	119
Peas, frozen, film-packaged, effect of illumination on color of	539
Peas, green, canned, degradation of chlorophyll to pheophytin during heat sterilization of	281
Pectin, preparation of, from raw papaya	553
Pectin standardization	496
Peroxidase inactivation in HTST processing of whole kernel corn	410
Pesticides, effects of, on flavor of frozen strawberries	587
Pheophytin, degradation of chlorophyll to, during heat sterilization of canned green peas	281
Physical constants of concentrated grape juice in relationship to the naturally occurring tartaric acid therein	4
Pinking of onions during dehydration	391
Potato peelers, small capacity commercial, evaluation of various types	276
Potato products, dehydrated, microscopic method for counting ruptured cells in	574
Potato texture, relation of chemical composition and physical properties to	183
Potatoes, canned, sloughing in	456
Potatoes, french-fry, prepeeled, control of exudation in, with antibiotics	485
Potatoes, sweet, frozen, quality of sliced, precooked	448
Potatoes, white, granules, color standards for	30
Poultry meat, post mortem aging of, effect on tenderness of breast muscle	81
Poultry meats, shelf life of, use of resazurin reduction test for estimating	584
Poultry products inspection, Public Law 85-172	731
Poultry products, tenderness of, as affected by processing techniques	689
Poultry tenderness, turkeys, influence of processing on	20
Pork carcasses, effect of fatness on some processing and palatability characteristics of	236
Pork, cooked, irradiated, antioxidants in	635
Pork, frozen, effect on storage life of tocopherol supplementation	313
Pork luncheon meat, canned, effect of metallic iron on spoilage of	650
Pork sausage, irradiated, storage characteristics of	405
Preference, measurement of, for food combinations	379
Preserves, strawberry, effect of 43 years' storage on	525
Pressure packaged foods	567, 571
Pressure, used as measure for beef tenderness	155
Processing conditions affecting tomato juice yield	270
Processing, influence of, on tenderness of chicken meat	25
Processing, influence of, on tenderness of turkey meat	20
Processing of food fats, a review	41
Processing, raw tomatoes, procedures for determining grades	62
Protein requirements, dietary, and supplementation	597
Pyrrolidonecarboxylic acid formation during production of beet puree	92
Quality control of fishery products, use of grade standards in	249
Quality evaluation and composition of boysenberries for frozen pies	645
Quality of apple wine, effect of fruit variety and maturity on	676
Quality of raw, blanched, and canned vegetables, slurry flow measurements as a method to determine	694
Radiate, irradiate, distinction of meaning	346
Radiation distillation apparatus for using high energy electrons in connection with radiation preservation of milk, milk products	94
Radiation induced chemical changes in raw beef	501
Radiation, ionizing, applied to potato tubers	159
Radiation of grain-infesting pests	58
Radiation pasteurization, gamma ray, of whole eviscerated chickens	75
Radiation preservation, gamma, effect on color, chlorophyll retention, carotenoid retention (carrots, sweet potatoes, green beans, broccoli)	352, 358
Radiation preservation of milk, bactericidal effects of cathode rays, gamma rays, ultraviolet light on	272
Radiation preservation of milk, milk products, radiation-distillation apparatus for using high energy electrons	94
Radiation preservation, storage characteristics of some irradiated foods (chicken meat and sweet potatoes, pork sausage, scallops)	398, 405
Radioprotective agents, role of, and effect of ionizing radiation on gelatin	624
Rapid determination of the quality of whole eviscerated haddock	224
Rapid method for production of sparkling apple wine	673
Ready-to-cook, cut-up chicken, frozen, time-temperature tolerance of	477
Resazurin reduction test for estimating shelf life of poultry meats	584
Resazurin reduction test for microbiological quality of processed poultry	578
Riboflavin, light destruction of, in partially baked rolls	527
Rice, canned, pearl, reduction of cohesion in	473
Rigor, reactions involved in, and meat tenderness	652
Rolls, partially baked, light destruction of riboflavin in	527
Sanitation, cannery, use of chlorine dioxide for	179
Scallops, storage characteristics of irradiated	405
Sensory evaluation of beef quality related to chemical evaluations	492
Sensory panel evaluations, glossary of terms used in	733
Shelf life of poultry, extension of, by edible protective coatings	146
Simulated sausage products, non-meat, use of isolated soy bean for	307
Sloughing in canned potatoes	456
Slurry flow measurements to determine quality of raw, blanched, canned vegetables	694
Sodium, benzoate and sodium sorbate in apple cider, taste thresholds for	84
Sodium chloride accumulation in the curing of ham	441
Sodium chloride, effect of, on cured meat inoculated with *Cl. botulinum*	509

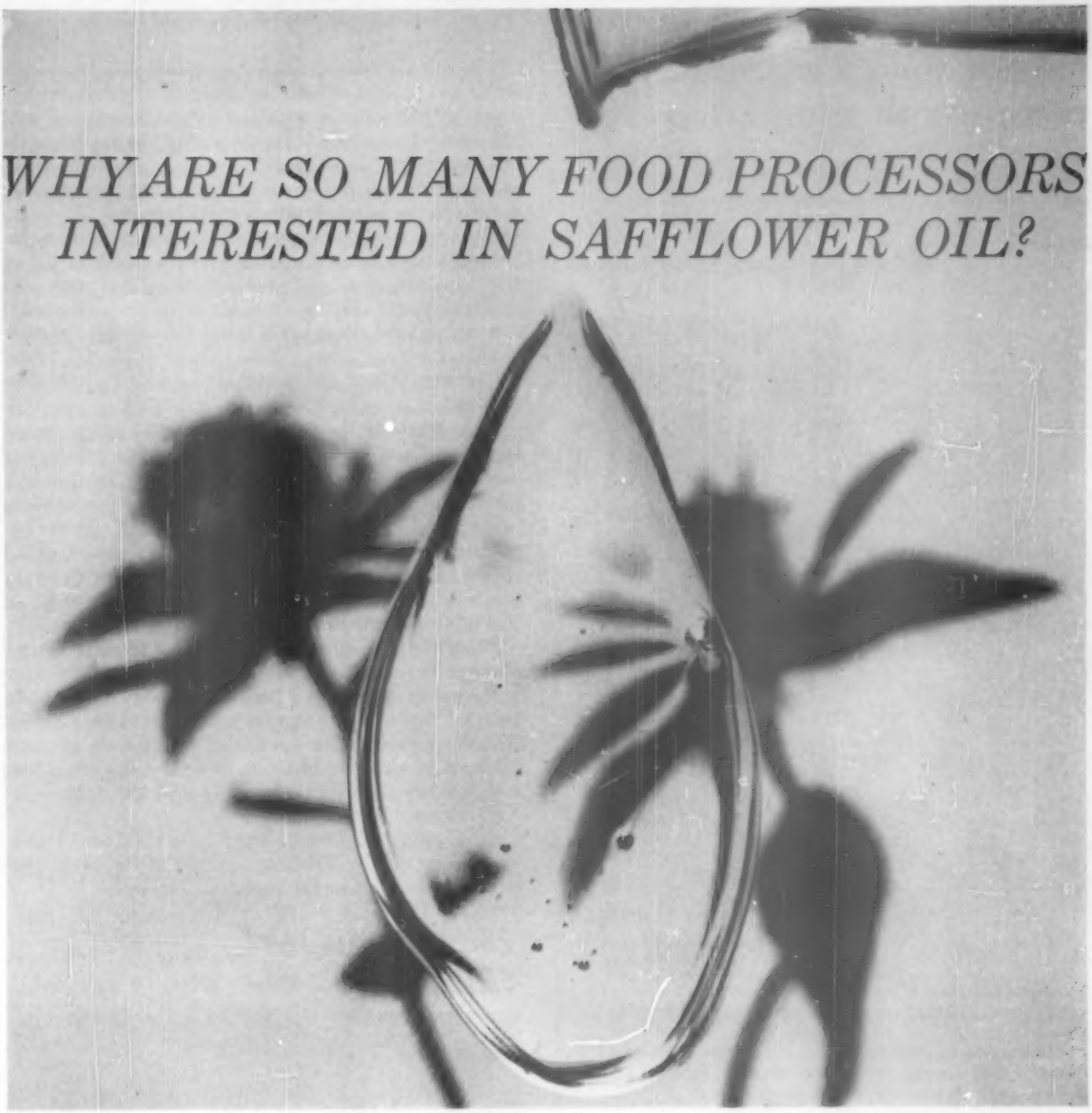
Subject	Page
Sodium sorbate and mild heat for preserving fruit products	251
Sodium sorbate and potassium to extend shelf life of smoked fish	459
Soup mixes, freeze-dried, storage stability of	36
Soybean, isolated, use for non-ment, simulated sausage products	307
Spoilage organisms on commercially processed fryers, influence of Aeronizing on	153
Stability in storage of freeze-dried soup mixes	36
Standardization, pectin, final report of IFT Committee on Pectin Standardization	496
Standards of identity, the pro and con	547
Starch chemistry for the food technologist	1
Stickiness and graining in stored hard candies	433
Storage, 43 years, effect of, on strawberry preserves	525
Storage rot susceptibility of potato tubers exposed to minimum sprout inhibiting levels of ionizing radiation	139
Storage stability of orange juice powder	113
Strain gage pea tenderometer, evaluation and description of the instrument	119
Strawberries, frozen, flavor of, as affected by certain pesticides	587
Strawberry ice cream, sugar in, consumer preferences for	107
Strawberry preserves, colorimetry of	303
Subtilin and nisin, use of, to lower heat process requirements of canned foods	462
Sucrose, citric acid, corn syrup, effect on consumer acceptance of, in freestone peaches	444
Sugar, effect of, on dill pickle quality	489
Sugar in ice cream, consumer preferences for	107
Sulfhydryl compounds, sulfur dioxide, hydrogen sulfide, components of coffee brew, effect of high temperature holding upon	679
Sweet potatoes, effect of gamma irradiation on color of	352
Sweet potatoes, irradiated, storage characteristics of	398
Sweet potatoes, precooked, frozen, quality of	448
Sweetness, consumer preference for, in sirup packed, red sour pitted Montmorency cherries	300
Tartaric acid, naturally occurring, related to certain physical constants of concentrated Concord grape juice	4
Taste thresholds for sodium benzoate and sodium sorbate in apple cider	84
Temperature histories of frozen foods, use of, to estimate frozen food quality	14
Tenderness in beef muscle as measured by pressure	155
Tenderness of meat, reactions involved in rigor affecting	652
Tenderness, poultry meat, at various muscle depths, as affected by processing techniques	689
Tenderness of poultry meat in relation to post mortem aging	81
Tenderness of poultry meat, effect on, of processing	20, 25
Tenderometer, strain gage, pea	119
Terms used in sensory panel evaluations, a glossary of	733
Time-temperature tolerance of frozen foods, effect of blanching conditions, frozen beans	258
Time-temperature tolerance of frozen foods, frozen fried chicken	221
Time-temperature tolerance of frozen foods, frozen green snap beans in retail packages	136
Time-temperature tolerance of frozen foods, method of using temperature histories to estimate quality	14
Time-temperature tolerance of frozen foods, ready-to cook cut-up chicken	477
Tin plate, differentially coated, for food containers	228
Tocopherol supplementation of swine rations on frozen pork storage life	313
Tomato, fouling of evaporator tubes by, during drying	691
Tomato juice, effect of processing conditions on yield	270
Tomato ketchup, adulterants in, spectrophotometric method for detecting	414
Tomato powders, vacuum dried, microscopic structure and reconstitution of	561
Tomato products, commercial scale evaporation of, in flash evaporators	232
Tomato products, interpreting mold counts of	318
Tomatoes, canned, pH problem in	418
Tomatoes, raw, procedures for determining grades for	62
Trimming time, yield factors in processing apple slices	186
Turkey, tenderness of, influence of processing on	20
Ultrasonic defrosting of frozen foods	109
Uniformity of color measure in green beans	711
Vacuum drying, continuous	217
Vacuum puff drying, fruit and vegetable juices	341
Valencia orange powder, carotenoid pigment changes in, during preparation, storage	394
Vanilla extract, an improved lead number determination	730
Vegetable and fruit juices, behavior during vacuum puff drying	341
Vegetables, raw, blanched, canned, method to determine quality	694
Viscosity of concentrated orange and grapefruit juices	9
Visible fats in our diet	46
Visual and eating preferences of consumer household panel for beef from animals of different age	332
Volatile reducing substances of components of coffee brew held at high temperatures	383
Water-vapor transfer through food packaging films	69
What consumers expect from food standards	544
White potato granules, color standards for	30
Wine, apple, effect of fruit variety and maturity on quality of	676
Wine, Sparkling Apple, rapid method for production of	673
Yield factors in processing apple slices	186

Book Review Index, Volume 13, 1959

	Page
ADVANCES IN FOOD RESEARCH, Vol 8, Ed. by E. M. Mrak and G. F. Stewart. (J. H. Hulse) (7)	32
THE CHEMISTRY AND TECHNOLOGY OF CEREALS AS FOOD AND FEED. Ed. by Samuel A. Matz. (E. Everett MacDonough, Jr.) (12)	23
COMMERCIAL FRUIT AND VEGETABLE PRODUCTS. 4th Edition. W. V. Cruess. (Charles Feldberg) (3)	20
FOOD: THE YEARBOOK OF AGRICULTURE, 1959, USDA. (M. S. Peterson) (12)	22
FOOD MICROBIOLOGY. By W. C. Frazier. (R. O. Wagenaar) (5)	36
LIVING RESOURCES OF THE SEA: OPPORTUNITIES FOR RESEARCH AND EXPANSION. By Lionel Walford. (Melvin A. Benarde) (5)	34
MANAGEMENT HANDBOOK: TO AID EMERGENCY EXPANSION OF DEHYDRATION FACILITIES FOR VEGETABLES AND FRUITS. Prepared by the USDA Research Service, Albany, California. (Martin S. Peterson) (8)	37
OUR DAILY BREAD. By E. J. Pyler. (Charles Feldberg) (2)	27
POTATO PROCESSING. By William F. Talburt and Ora Smith. (Albert C. Rauch) (10)	46
PROCESSED PLANT PROTEIN FOODSTUFFS. Ed. by A. M. Altschul. (Charles Feldberg) (4)	32
RECOMMENDED METHODS FOR THE MICROBIOLOGICAL EXAMINATION OF FOODS. American Public Health Association. (J. Orvin Mundt) (8)	54

ERRATA, VOLUME 13

FOOD TECHNOLOGY, 13, page 305 (1959): The heading, "Significance of $Tan^{-1} a_L$ Values" should read—"Significance of $Tan^{-1} \frac{a_L}{b_L}$."



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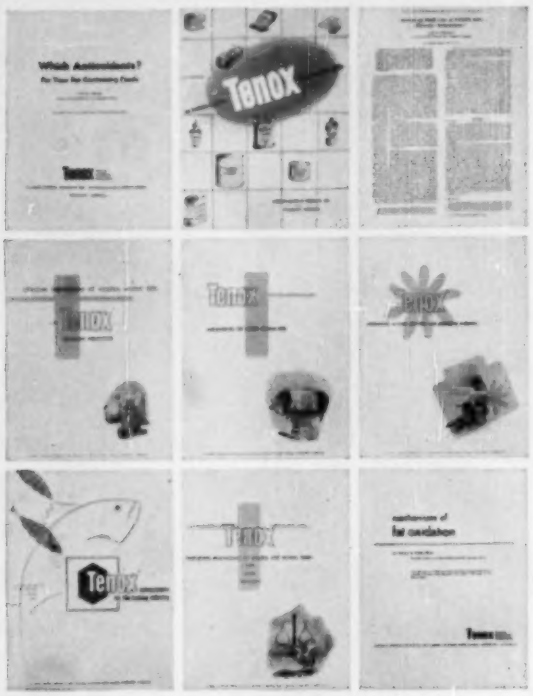

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(Continued from page 14 preceding technical section)

9:00 a.m.) session will consider the "Processing" phase of the subject with the afternoon session considering "Packaging," the Saturday session being on "Acceptance." A "free for all" question and answer period will follow the sessions with the audience as well as the panel members participating.

Through the co-operation of university and industry personnel an outstanding group of authorities on the various aspects and problems associated with convenience foods will he on hand to serve on the various panels, and present the latest information in their fields.

The program of the Section, past and future, is as follows:

September 21, 1959. Dinner Meeting at the Hotel Gatesworth. Mr. Dan Ridenour, Technical Director of Wm. J. Stange Co. discussed the recent advances in technology of spices and seasonings and their effects upon our acceptance of foods.

November 16, 1959. Dinner Meeting at the Hotel Gatesworth. Mr. Byron Spence of Marine Colloids, Inc. spoke on the "New Developments in the Application of Gums and Stabilizers to the Food Industry."

February 8, 1960. Ladies' Night—Theatre Party, Webster Grove's Little Theatre.

March 11–12, 1960. Eighth Annual Food Technology Short Course, "Impact of Convenience Foods." Two day panel discussion conference at University of Missouri, Columbia, Mo. Co-sponsored by St. Louis and Kansas City Sections, IFT, and the College of Agriculture.

April 18, 1960. Dinner Meeting at the Hotel Gatesworth. "Dehydro-Freezing of Foods" will be the topic discussed. Annual business meeting.

—Charles M. Harrold

TEXAS

TEXAS SECTION MEETING—This group comprised some of the leaders and speakers at the Texas Section of the Institute of Food Technologists' annual fall session held Oct. 10 at Texas A. and M. College. Left to right are Ken Keneaster, director of quality control for Converted Rice, Inc., of Houston and president of the Texas Section; Dr. Imri Hutchings, director of research for the H. J. Heinz Company at Pittsburgh, Pa., and the meeting's main speaker; Dr. E. E. Burns, associate professor in the A. and M. Horticulture Department and counselor of the Texas Section, and Dr. Isaac Peters of the A. and M. Dairy Science Department and Texas Section past president. Dr. Hutchings discussed "Food and the Food Technologist." The institute is a technical organization of persons working in the commercial foods industry.

WASHINGTON, D. C.

The Washington Section met in the NCA building September 29, at 8 p.m. EDT which was at the start of the 10th inning of the second game of the Dodgers-Braves playoff series. Even so, about 75 members were present. Chairman Bill Hoover announced that the Section has grown to 150 members, of whom 90 are also members of the national society. After a short business meeting, the membership was privileged to hear Dr. Dale Lindsay of the National Institute of Health discuss the research grants program of that organization. These research grants, under authority of Public Law 410, are used to encourage and finance research on problems of national health as interpreted in the broad sense. Grants are made in the names of individual scientists under the sponsorship of research institutions. Grant subjects of interest to food technologists include the effects of processing methods on nutritional quality, basic studies in enzymology and other aspects of food biochemistry, and possible biological implications of certain food additives and residues. Broad latitude in subject area is not only permitted, but encouraged in this program according to Dr. Lindsay. Applications for grants receive a dual review, the first being a technical evaluation by study groups and the second, a study to develop policy and action, made by a research council. The membership of these review groups is primarily that of well-known scientists in the various fields of research.

—A. P. Sidwell

NEW YORK

The Section's 1960 meetings, to be held at the Brass Rail, 40th Street and Park Avenue, New York City, New York, are as follows:

January 20—Dr. K. Durrenmatt, The Nestle Company, speaking on Instant Beverages.

February 17—Dr. I. J. Hutchings, President-Elect, Institute of Food Technologists, whose subject will be Food and the Food Technologist. Mr. F. K. Lawler, Editor, *Food Engineering*, will give a discussion of European Foods and Processing.

March 16—Mr. Lloyd Stouffer, Editor, *Modern Packaging*, will discuss Packaging and Food Additives Amendment.

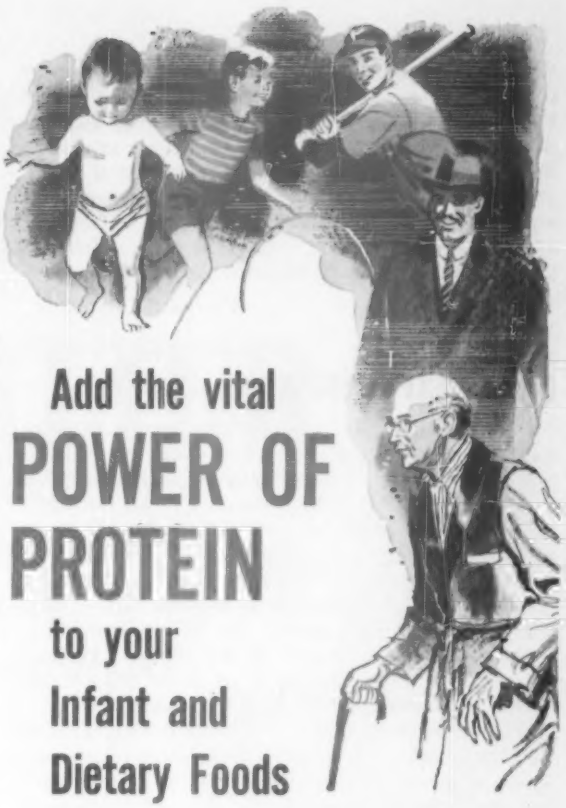
April 20—Mr. Fred Butt, Dow Chemical Company, speaking on Chelating Agents.

May 12 (Thursday)—Ladies' Night—Miss Maye Russ, National Better Business Bureau, discussing Some Facts and Fancies in Food Advertising.

—Stanley De Nisco

MARYLAND

The Maryland Section of the Institute of Food Technologists held their monthly meeting at the Stafford Hotel in Baltimore on October 16, 1959. Dr. Arthur M. Kaplan, QM Research and Engineering



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Commond, Natick, Mass., gave an informal talk on the subject, "Prevention of Deterioration and Contamination of Materiel." Dr. Kaplan explained how micro biological deterioration could occur in textiles, wood, paper, leather, and plastics. A general outline was presented to show how chemicals are evaluated and some of the tests used in the field before final approval can be made. An interesting discussion perio l followed with 29 members participating.

—*Warren E. Anderson*

N. CALIFORNIA

The Section is most proud of the recent inauguration of Emil M. Mrak, one of our long time distinguished members of world renown, as chancellor of the Davis Campus of the University of California on October 23. The colorful ceremony was presided over by U. C. President Clark Kerr.

San Francisco-born Chanc lor Mrak, a graduate of the University of California at Berkeley and a member of the university faculty for 33 years as a professor of food technology, was for the past 11 years Chairman of the Department of Food Science and Technology. His special field is the yeasts.

In his inaugural address "The University and the Ecology of Man" Mrak stressed the inter-relationship of the sciences and the liberal arts at Davis, which last year was designated by the university regents as a general campus. It had been the university's college of agriculture since 1906. "The general campus at Davis is and will be the University of California for Northern California and the Central Valley" Mrak declared. "We must regard ourselves as the center of an intellectual community which does not end at the campus gates, but stretches out widely."

On November 12 there was a joint meeting of the Northern California Section of IFT with its Delta and San Joaquin Valley SubSections at the Hotel Covell in Modesto. Prior to the dinner there was a wine tasting session under the direction of Dr. Maynard A. Amerine. "Practical Problems in the Sensory Examination of Foods" was discussed, after dinner, jointly by Dr. Amerine, Professor of Enology and Miss Marion Simone, Department of Food Science and Technology, both from the University of California, Davis.

In conjunction with the meeting, and to promote fellowship and an increased turn-out for the evening joint meeting, the annual IFT Golf Tournament was held at 11 o'clock in the morning at the Tracy Country Club.

Annual All-Day Meeting

Our annual all-day meeting was staged this year on Thursday, December 3, at the Claremont Hotel, Berkeley, California. The morning program opened with a short business meeting presided over by Chairman Bruno A. Filice followed by general papers under the Chairmanship of George F. Stewart. After luncheon, the afternoon sessions were divided into two parts: A—Materials Handling with Ray Junk as chairman and B—Sampling, under the chairmanship of Abe Mittler. In the evening Dr. Max Kleiber spoke on "Growth of Population and Food Supply."

This was the program for the day with subjects and speakers:

Morning—General Papers—George F. Stewart, Chairman

1. Factors Affecting pH Control and Acidification of Tomatoes, Frank C. Lamb—National Canners Association, Berkeley, Calif.
2. Food Research in Western Europe
   William F. Talburt, Sigmund Schwimmer and D. G. Guadagni, Western Utilization Research & Development Division, Albany, Calif.
3. Beware the Fifth of March
   Bernard L. Oser—Food & Drug Research Laboratories, New York, New York
4. Applications of Capillary Gas Chromatography in Food Chemistry
   Roy Teranishi and J. W. Corse, Western Utilization Research & Development Division, Albany, Calif.
5. A Synergistic Effect of Amino Compounds on Phenolic Antioxidants for Fats and Oils
   H. S. Olcott and E. J. Kuta, Dept. of Food Science and Technology, University of California, Berkeley

Afternoon—A: Materials Handling—Ray Junk, Chairman

1. Bulk Materials Handling
   H. M. Lauritzen—California and Hawaiian Sugar Refining Corporation, San Francisco, California
2. Plant Materials Handling by Pumping and Fluming
   Claude J. Artero, California Packing Corporation, San Francisco, California

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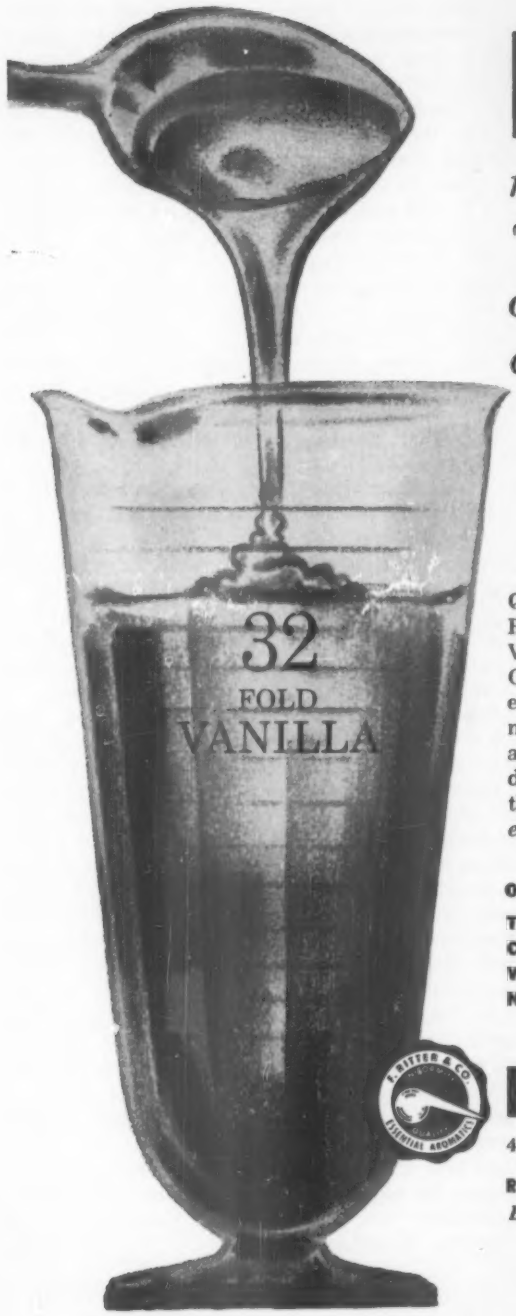

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3. Sanitation Aspects of Hydraulic Conveying of Food Products
   Walter A. Mercer, National Canners Association, Berkeley, California
4. Flow Problems of Liquid Food Products
   John C. Harper, University of California, Davis, Calif.
5. Panel Discussions

Afternoon—B: Sampling—Abe Mittler, Chairman

1. Acceptance Sampling—Its Application to Metal Cans
   Stanley J. Hotchner—American Can Company, San Francisco, California
2. Preparation and Operation of a Third Party Grading System
   S. R. Whipple—State of California Department of Agriculture, Sacramento, California
3. Developing a Sampling Procedure for Raw Products
   Gordon A. Rowe—University of California, Berkeley, Calif.
4. Some Practical Considerations for In-Process Sampling
   C. R. Sheaffer, Stokely Van-Camp, Inc., Oakland, Calif.
5. Panel Discussions

—Shirley V. Noland

WISCONSIN

The Fall program of the Wisconsin Section IFT opened with a tour of the Kurth Malting Company facilities at Milwaukee on Friday, September 25. About fifty members and guests viewed with great interest the production of this ingredient so vital to the production of Wisconsin's most famous product.

Following the dinner meeting, Dr. Eric Kneen, Director of Research of the Kurth Malting Company, spoke to the group about the production of malt and the many factors involved in preparing malts with desirable brewing characteristics. In spite of the Braves' loss to the Dodgers that rainy evening in Milwaukee, the meeting was enjoyed by all who attended.

—John J. Birdsall

Literature

BOOKS

FOOD: THE YEARBOOK OF AGRICULTURE 1959. The U. S. Department of Ariculture, Washington, D. C. (For sale by the Superintendent of Documents, Washington 25, D. C. Price $2.25.)

It takes a book like *Food: The Yearbook of Agriculture 1959* to remind one that U. S. Department of Agriculture research is a stable, well-integrated, creative enterprise that has contributed immeasurably to national health and welfare—two essentials to the successful "pursuit of happiness." The tangible benefits of agricultural and food research to the taxpayer far outweigh the appropriations he has sanctioned.

"Research—agricultural research, food research—must go forward." So states Ezra Taft Benson, Secretary of Agriculture, in the Foreword to *Food*. The maturity and competency of USDA research leadership and the momentum generated by research discoveries to date indicates that it *will* go forward. The problems ahead, however, are more complex than those solved and left behind. As one example of many, there are as yet unidentified factors in food—antitoxic factors, growth factors, nutrients — that, when identified, will be as important and exciting as the discovery of the vitamins. At the moment, however, only their presence has been determined. Some intricate, painstaking laboratory work remains to be done to get their names and numbers.

The scope of *Food* includes nutrients and nutrition, health, recommended allowances, food needs for young and old, food quality, home preparation of food, costs, trends, new food products, food habits, feeding programs, and a glance at the years ahead with regard to the food supply, population growth, and nutritional status.

It is not the claim, much less the intent, of those who organized and wrote *Food* that all food research and development progress stems from the USDA. The goal, in fact, was to present a "solid, authoritative, complete book that would put nutrition in proper perspective and counteract some of the nonsense or half-truths about food . . ." In so doing, Alfred Stefferud, editor, Hazel K. Stiebeling, chairman of the yearbook committee, and scores of specialists in nutrition, food chemistry, and biochemistry, food technology, marketing, and consumer testing have drawn not only from USDA studies but from many sources outside the Department. The end result is a book that defines the position of food and nutrition as of 1959, and comments on, or reviews, a considerable part of the vast accumulation of new knowledge in these fields. It also manages, without didacticism, to convey the precept that good nutrition is vital to the individual, to the community, to the nation, and to the world. Teaching proper nutrition has long been an important function of the Department.

Indicative of what can be found in this book, here are a few of the topics considered: the relation of food energy to energy expenditure (e.g., piano playing [Mendelssohn] can be accomplished on an expenditure of 56 calories per hour; sawing wood costs 399 calories per hour); the nature of, and the bodily requirements for, proteins; the role of fats in the diet (saturated and non-saturated); control of bodily weight; functions of the trace elements in enzymatic actions; research considerations in the development of new foods; the pure food law; and some interesting food trends. With regard to trends, we are told in *Food* that we are eating meals away from home in greater degree than ever before—13% in 1929, 17% in 1958. This suggests that we are constantly increasing our purchasing power and our tendency to urbanize—and decreasing our interest, somewhat, in preparing meals at home.

Food is a readable book. Too bad you cannot get it, among the paperbacks, at your nearest newsstand. But sending your order to the Superintendent of Documents, Washington 25, D.C. is well worth the effort.

MARTIN S. PETERSON
Chicago, Illinois

THE CHEMISTRY & TECHNOLOGY OF CEREALS AS FOOD AND FEED. 1959. S. Matz, Editor. The Avi Publishing Company, Inc., Westport, Connecticut.

As the title denotes this is a survey of the chemistry and technology of cereals as food and feed. The book is not the work of a single author but rather the summation of the knowledge of 23 persons who are specialists in the fields about which they have written. Because of this the information presented is for the most part general but also practical and up to date.

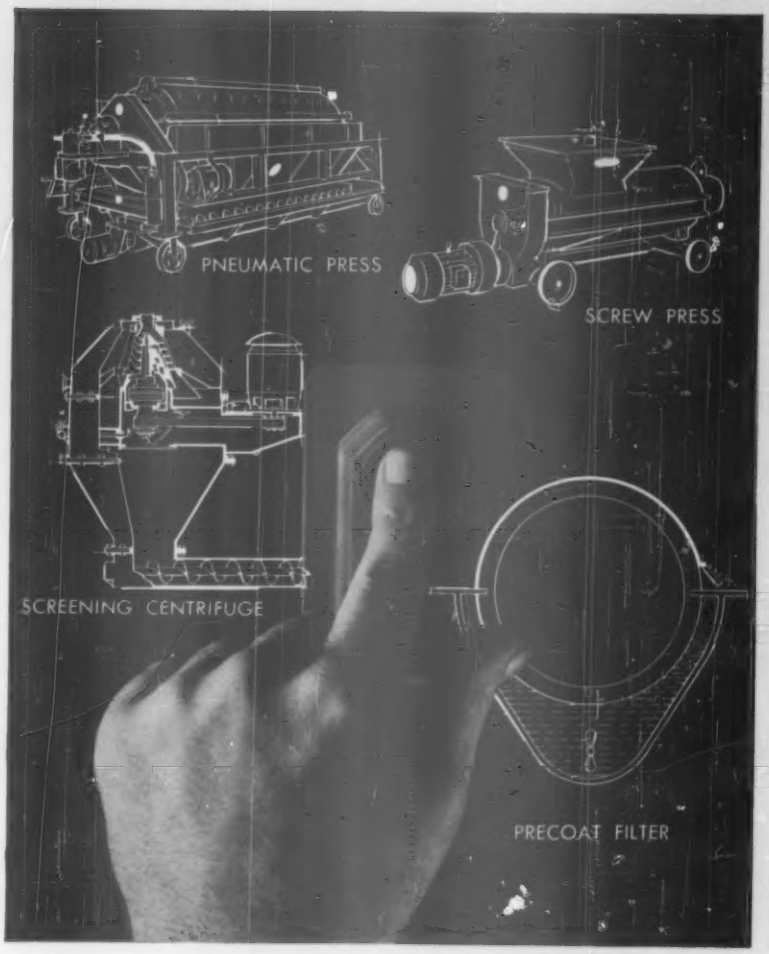
The first eight chapters contain a detailed discussion of the production of cereal grains, their composition and quality characteristics. Included are chapters on wheat, corn and oats.

Section two covers in detail the processing methods of current importance in this industry. Among the chapters are ones on milling, wet-milling, malting, brewing, manufacture of oils, and feeds. Of special interest are the excellent chapters on macaroni production, commercial baking procedures, prepared mix manufacture and breakfast cereal production.

Especially worthy of note is the chapter on commercial baking procedures. Here the reader is offered an easy to read summary of the more important aspects of baking. Those of us who are not bakers will, after reading this chapter, have a better appreciation of this important area of Food Technology. The emphasis in this chapter is, as it should be, on bread baking. Following this is a somewhat shorter discussion covering the highlights of the production of cakes and pies.

The chapter on prepared mixes is one of the few I know of covering this aspect of the industry in which as the author notes "seecrecy is frequently resorted to in an attempt to guard any new developments." With this as his premise the author is still able to present much useful and interesting information on this expanding area of interest.

The final section discusses the chemical, physical and physiological properties of various components of cereals and cereal products. Of especial interest is the chapter dealing with the adequacy



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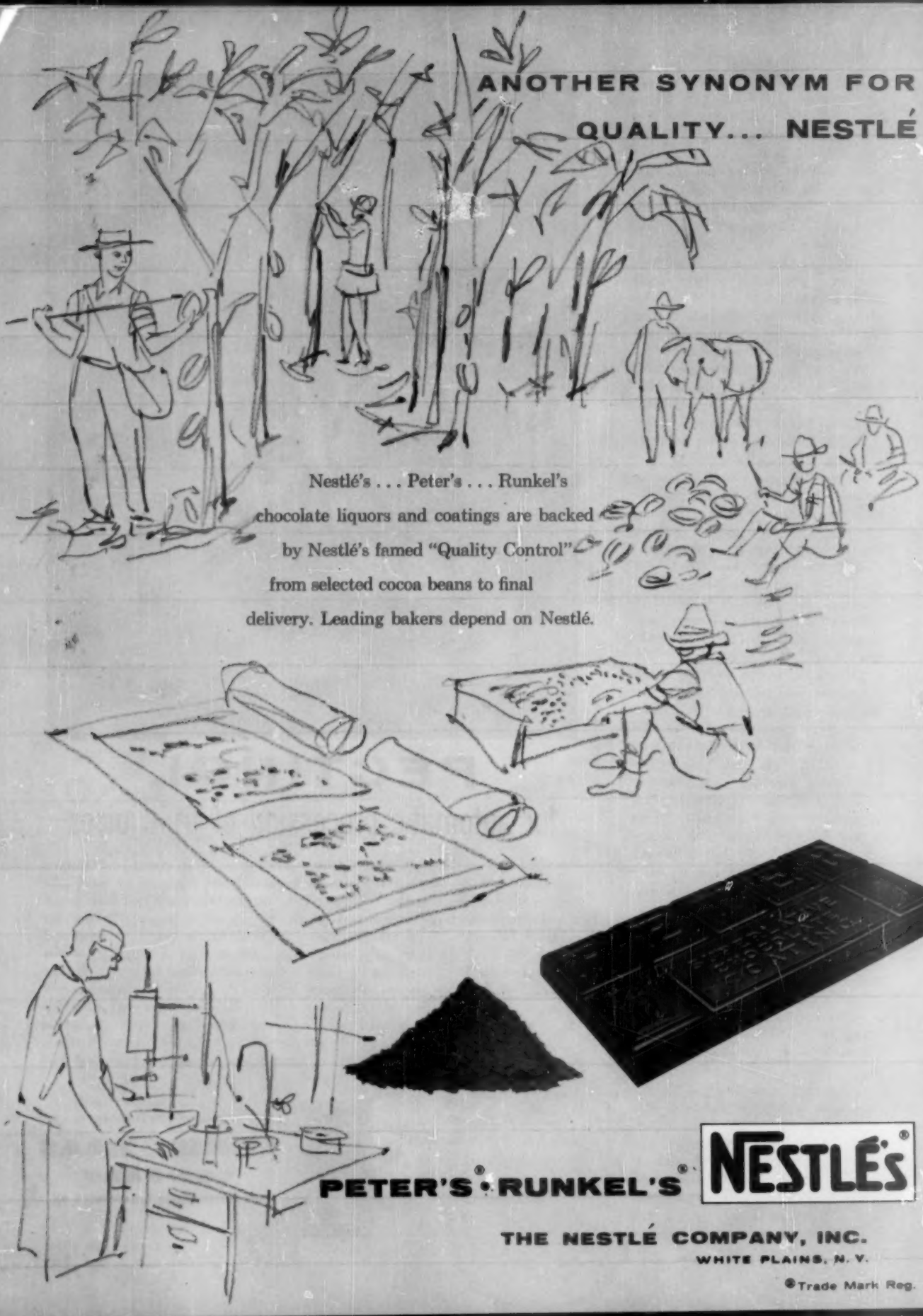

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of processed cereals in human nutrition. The discussion includes an up-to-date discussion on the protein and amino acid composition of cereal foods. Recently, the lysine deficiency of various cereals has received a large amount of publicity and a review of this interesting subject and some of its ramifications are covered. Further discussion of the nutritional value of cereals includes a coverage of their carbohydrate and fat content and the use of vitamins which has become increasingly popular. In this latter area both the enrichment of standardized cereal products and the use of other vitamins such as ascorbic acid, pyridoxine (B_6) and vitamin B_{12} are discussed.

This book is generally well-written and interesting. It is highly recommended as a textbook for college students, a reference book for food technologists whether in the baking or cereal industry or not. This book also should be of interest to others whose interest lies in the study of foods such as home economists and nutritionists.

E. EVERETT MACDONOUGH
Brooklyn, New York

ABSTRACTS

General Foods Research Center
Selected by H. A. Campbell

ANALYTICAL METHODS

Analysis by gas chromatography of a 'pure' sample with an 'impure' carrier.

WILLIS, V. (Imp. Chem. Inds., Ltd., Engl.). *Nature 183*, 1754 (1959).

Chromatographic analysis of a gas contg. impurities was accomplished using a carrier gas with the same impurities in a higher concn. It is assumed that impurities in the carrier gas sample formed an equilibrium down the column. When a gas stream of known purity is used as the carrier, 'negative peaks' are possible when deficiencies of components occurred in the sample compared with the carrier.

Molecular sieves in organic chemistry.

LOWENBERG, P. *J. Appl. Chem. 9*, 417–20 (1959).

Potential uses of mol. sieves in org. analysis and synthesis have been investigated and critical dimensions of simple org. compds. have been calcd. Results show promising applications of this new tool for lab. and industrial purposes, particularly in the field of sepn. of mixts. and as a reagent carrier.

BIOLOGICAL SCIENCES

Biochemistry

Notes on the qualitative detection of cysteine on a photographic basis.

SCHWARZENBACH, F. H. *Helv. Chim. Acta 42*, 1103–41 (1959).

The method exploits the observation that drops of a cysteine soln. which act on a film layer are, after exposure and photographic developing, distinguishable as light spots on a dark background.

Studies on the structure and methylation of wheat glutenin.

OXENDER, D. L. (Purdue Univ., Lafayette, Ind.). *Dissertation Abstr. 20*, 61–2 (1959).

The chemistry of the action of dimethyl sulfate on glutenin was studied to det. the sites of methylation. It is concluded that gelation of methylated glutenin is a result of a weakening of the electrostatic bonds which, in turn, is caused by the esterification of the carbonyl groups during the methylation procedure. On the basis of the author's expts. and on evidence presented in the literature several structures are presented and discussed.

A new general method for the isolation of anti-protein antibodies.

SINGER, S. J., FOTHERGILL, J. E. AND SHAINOFF, J. R. (Yale Univ., New Haven, Conn.). *J. Am. Chem. Soc. 81*, 2277–8 (1959).

Proteins have been thiolated with Ag catalyst by the Benesch method [Proc. Natl. Acad. Sci. U. S. 44, 848 (1958)]. Removal of Ag^+ at the conclusion of the reaction has been troublesome. Thiolation of ovalbumen was accomplished without Ag^+ by raising the pH from 7.5 to 10.7 and running the reaction 2 hrs. at 0° C. About 6.5 SH groups were coupled/protein mol.

A new method for the introduction of thiol groups into proteins.

KLOTZ, I. M. AND HEINEY, R. E. *J. Am. Chem. Soc. 81*, 3802–3 (1959).

Thiolation of gelatin and proteins was accomplished by adding (at room temp.) solid S-acetylmercapto-succinic anhydride to the protein soln. at pH 7. Air was excluded with nitrogen. Results showed that 30 to 360 moles of anhydride could be added/10^5 g. of protein.

Effects of thyroxin on amino acid incorporation into protein.

SOKOLOFF, L. AND KAUFMAN, S. *Science 129*, 569–70 (1959).

The effect of thyroxin on the in vitro incorporation of DL-leucine-1-C^{14} into the protein of rat liver homogenates has been investigated. Both thyroxin pretreatment in vivo and thyroxin in vitro at a concn. of $1 \times 10^{-5} M$ were found to increase the rate of amino acid incorporation. It is suggested that the acceleration of metabolic rate characteristic of thyroxin action may be secondary to the stimulation of energy-requiring reactions such as protein synthesis.

An effect of insulin on peptide synthesis independent of glucose or amino-acid transport.

WOOL, I. G. AND KRAHL, M. E. (Univ. of Chicago, Ill.). *Nature 183*, 1399–400 (1959).

Increases in the incorporation of amino acids were obtained despite the accumulation of amino acids before the addn. of insulin and despite the absence of added glucose. It is concluded that insulin can influence protein synthesis at a locus distal to amino-acid penetration and independent of glucose entry.

Body composition and in vitro synthesis of lipids by adipose tissue of 11-dehydrocorticosterone-treated mice.

HOLLIFIELD, G. AND PARSON, W. (Univ. of Virginia, Charlottesville). *Am. J. Physiol. 197*, 105–7 (1959).

11-Dehydrocorticosterone pellets implanted subcutaneously produced increased carcass fat and decreased protein in older mice but not in young mice of the DBA strain.

Effect of alfalfa saponin on laying chickens.

HEYWANG, B. W., THOMPSON, C. R. AND KEMMERER, A. (Univ. of Arizona, Tucson). *Poultry Sci. 38*, 968–71 (1959).

White leghorns were fed diets contg. no alfalfa saponin, 0.4% saponin extd. from alfalfa, or 0.26% saponin supplied by sun-cured alfalfa meal at the 20% dietary level. Both saponins depressed egg production. The effect was apparent during the entire exptl. periods, but disappeared soon after saponin feeding was stopped.

Microbiology

Estimation of coliform bacteria in ice cream by use of the membrane filter.

NUTTING, L. A., LOMOT, P. C. AND BARBER, F. W. (Natl. Dairy Products Corp., Oakdale, N. Y.). *Appl. Microbiol. 7*, 196–9 (1959).

Membrane filtration in conjunction with the use of dil. wetting agent has provided a direct one day method for the enumeration of true coliform bacteria in ice

cream. The method eliminates interference from sucrose and consequent false-positive reactions. Previously these false reactions could be overcome only through time-consuming isolation and identification procedures.

Nutrition

The protein allowance controversy.

ANON. *Nutrition Revs. 17*, 196–8 (1959).

It is noted that there are various points of view on what constitutes a proper allowance for protein intake for infants under six months of age. A review of the subject indicates that the factors involved in the controversy are lack of pertinent information, differences in interpretation of the terms "requirement" and "allowance", and a recognized need for parameters of measurement that are functional, such as resistance to infection or other types of stress.

Amino acid balance and imbalance.

HARPER, A. E. (Univ. of Wisconsin, Madison). *J. Nutrition 68*, 405–18 (1959).

A protein lacking tryptophan (gelatin) or an amino acid mixt. lacking threonine has been used to create amino acid imbalances involving tryptophan or threonine in diets contg. casein supplemented with methionine. The magnitude of the growth depression caused by the addn. of gelatin increased as the level of gelatin was increased. The magnitude of the growth depression caused by the amino acid mixt. lacking threonine was greatest when the diet contained 6% of casein and was less if the level of casein in the diet was lower or higher.

Growth rate and lysine requirement of the chick.

GRIMINGER, P. AND SCOTT, H. M. (Rutgers Univ., New Brunswick, N. J.). *J. Nutrition 68*, 429–42 (1959).

The influence of growth rate on the requirement of the young chick for lysine has been investigated. Variations in the growth rate were achieved by selecting fast- and slow-gowing individuals from one population, by adding a non-nutritive growth-depressant to the diet, by use of a fast- and a slow-growing group from two different breeds, and finally by intentionally infecting chicks with the virus of a respiratory disease (bronchitis). In all cases, the difference in growth rate did not appear to influence the lysine requirement, when growth, gain, or the instantaneous rate of growth per day were used as criteria of lysine sufficiency.

Lysine and methionine supplementation of corn soybean oil meal rations for pigs in drylot.

ACKER, D. C., CATRON, D. V. AND HAYS, V. M. (Iowa Agr. Expt. Sta., Ames). *J. Animal Sci. 18*, 1053–8 (1959).

Corn-soybean oil meal rations contg. 12% and 14% protein were supplemented with 4 levels of L-lysine and/or 4 levels of DL-methionine and fed to pigs. On the 12% protein ration, rate of gain and feed efficiency were improved by L-lysine, up to the 0.10% supplemental level. Lysine supplementation of the 14% protein ration exerted no consistent effect. Methionine supplementation of the 12% ration exerted no apparent effect on either gains or feed conversion.

Amino acid supplementation of a corn diet.

ANON. *Nutrition Revs. 17*, 201–3 (1959).

Nitrogen balances were conducted on children to assess the value of amino acid supplementation of a corn diet. Results suggest that the FAO pattern of amino acid requirements represents a reasonable point of reference for evaluating the amino acid adequacy of a diet composed largely of corn, with the possible exception that the suggested methionine level is in excess of need.

Dietary protein and serum cholesterol.

ANON. *Nutrition Revs. 17*, 215–18 (1959).

The influence of animal protein intakes on serum cholesterol concn. in animals and man was studied. Indications were that serum cholesterol concn. is influenced by the dietary level of protein, and that the protein effect may in turn be influenced by the concn. of lipotropic factors in the diet.

The increased severity of atherosclerosis in rabbits on a lactose-containing diet.

WELLS, W. W. AND ANDERSON, S. C. (Univ. of Pittsburgh, Penna.). *J. Nutrition 68*, 541–9 (1959).

Rabbits fed 0.35% cholesterol-contg. diets with 29.35% lactose as carbohydrate were found to have higher serum cholesterol levels, higher total liver cholesterol concn., and higher scores toward atherosclerosis than those fed 0.35% cholesterol with 20.35% sucrose as carbohydrate.

Dietary effects on human milk fatty acids.

ANON. *Nutrition Revs. 17*, 203–5 (1959).

A study was made of the effects of controlled variation in diet on the compn. of fatty acids of human milk. Diets of lard, corn oil and non-fat diets were fed. The human milk fatty acids reflected the compn. of the fat in the diet. When no fat was fed, mammary synthesis of lauric and myristic acids predominated.

The effect of dietary fat on vitamin B_{12}-methionine interrelationships.

FOX, M. R., ORTIZ, L. O. AND BRIGGS, G. M. (U. S. Dept. of Health, Educ., and Welfare, Bethesda, Md.). *J. Nutrition 68*, 371–81 (1959).

Increasing the fat content of the diet increased the severity of the vitamin B_{12} deficiency. This effect of high dietary fat was lost in the presence of supplemental methionine; however, both vitamin B_{12} and methionine were necessary for maximum growth. With no fat in the diet, growth depression in the absence of vitamin B_{12} was very small. In the absence of fat the toxicity of methionine was markedly increased.

Production of dietary vitamin K deficiency in the rat.

MAMEESH, M. S. AND JOHNSON, B. C. (Univ. of Illinois, Urbana). *Proc. Soc. Exptl. Biol. Med. 101*, 467–8 (1959).

A diet is described which produces a severe vit. K deficiency in the rat in less than 10 days. The deficiency was manifested by prolonged plasma prothrombin times and hemorrhages. Daily menadione supplementation protected rats from the deficiency. Coprophagy appeared to be the means by which vit. K synthesized by the intestinal microflora becomes available to the rat.

C^{14} studies in carbohydrate metabolism. IV. Characteristics of bicarbonate pool system in the rat.

SHIPLEY, R. A., BAKER, N., et al. (Western Reserve Univ., Cleveland, Ohio). *Am. J. Physiol. 197*, 41–6 (1959).

Specific activity curves of expired air were obtained after the injection of $NaHC^{14}O_3$ into normal and alloxan diabetic rats in the postabsorptive and fasted state. The curves were analyzable into 3 constituent simple exponential functions. This suggested a pool system with 3 conjoined compartments.

Use of vegetables in infant feeding through the ages.

ADAMS, S. F. (Charity Hosp., New Orleans). *J. Am. Dietetic Assoc. 35*, 692–703 (1959).

The use of vegetables in infant feeding has been traced from Biblical times up to the present day. The controversy which exists in the introduction of vegetable feeding and in the field of solid feeding to infants is clarified.

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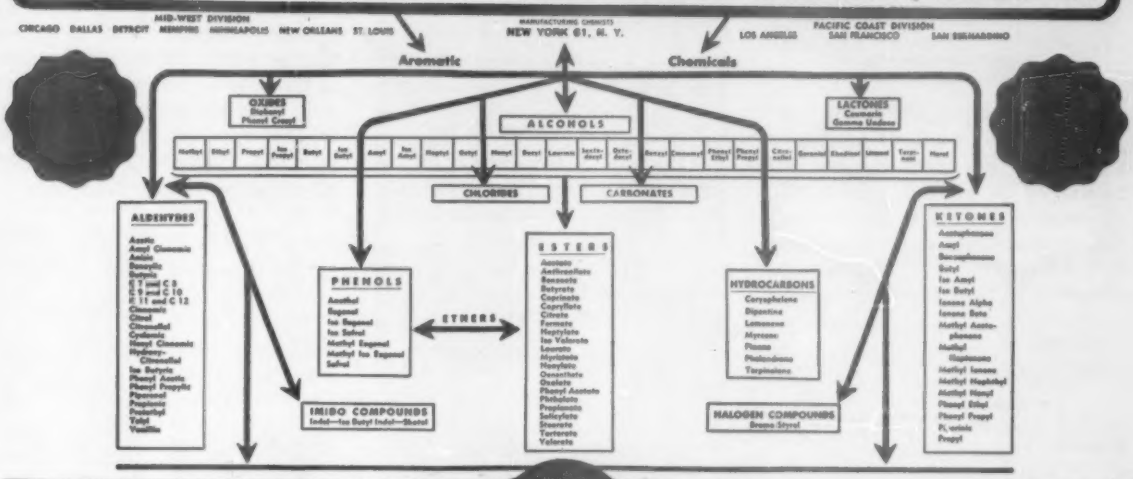

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INDUSTRY NEWS

PERSONNEL

Mr. Carl Swinehart has been appointed editor of FEED AGE and will direct the over-all editorial balance of the journal; namely the coverage of nutrition, production, and management developments. Mr. Swinehart, who majored in chemistry at the University of Chicago, began his career with the Research and Development Associates, Food and Container Institute, Chicago. He has been with FOOD AGE for the past several years.

Dr. I. W. Tucker is opening an office in Louisville, Kentucky with affiliates in New York and Washington, D.C. offering industrial research consulting services. Emphasis is on research planning and program development for new and improved products and processes. Special consideration will be given to the areas of his extensive experience in government and industry in the fields of complex natural products, foods, beverages, flavors, agricultural commodities, insecticides, enzymes and related products and processes.

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Appointment of **Dr. Wilbur S. Claus** as an assistant research director of the Carnation Research Laboratories, 8015 Van Nuys Blvd., Van Nuys, Calif., has been announced by Dr. Philip K. Bates, general manager of research for the food firm. A Carnation research staff member since 1947, Dr. Claus has been group leader in charge of development of products for the Company's Albers cereals and Simple Simon frozen foods divisions. He will remain closely associated with these products in addition to his new duties.

W. S. Claus

Carroll L. Griffith, President of The Griffith Laboratories, Inc. announces the promotion of **Dr. Louis Sair** from the position of Director of Research to the position of Technical Director. Dr. Sair is a graduate of the University of Manitoba and McGill University. He has been in charge of Research of The Griffith Laboratories, Inc. since 1946. Before joining The Griffith Laboratories, Inc., Dr. Sair was in charge of Protein Research at Central Soya Company. Prior to that, he was Research Fellow of the Corn

Louis Sair

Industries Research Foundation. Dr. Sair will be located in Chicago, which is the head office of The Griffith Laboratories, Inc.

The Directors of The Griffith Laboratories, manufacturing food chemists, have elected **Howard A. Levy** a Vice President to fill the post held by the late M. C. Phillips. Mr. Levy was Vice President and Cashier of the Commonwealth Bank of Chicago, prior to joining the Griffith organization in February 1933. He has served Griffith, first, as Purchasing Agent; later, transferred to sales, in which he has engaged for 24 years and will continue in charge of Chicago sales.

H. A. Levy

To help its personnel keep abreast of today's fast-moving technology, Chamberlain Laboratories has a large library, a corner of which is shown above. In addition to periodicals and reference works, the library has facilities for showing motion pictures and is the scene of frequent seminars.

EXPANSION NEWS

Chamberlain Laboratories, the new Research and Development center of The U. S. Stoneware Company, was formally dedicated here September 29, 1959, as a feature of U. S. Stoneware's Centennial celebration.

Ceremonies marking the event included an "open house" at Chamberlain Laboratories, which gave visiting representatives of science, industry and the press an opportunity to inspect the new facilities, followed by a dinner in nearby Akron, Ohio. Principal speaker of the evening was Dr. Foster Dee Snell, President of Foster D. Snell, Inc., who spoke of "Research Over Nearly Four Decades." Short talks were also given by Dr. Walter J. Murphy, editorial director of the various American Chemical Society publications, and Dr. Paul Bachman, vice president and director of research of Koppers Company, Inc.

Organized and equipped to meet the specific needs of The U. S. Stoneware Company, Chamberlain Laboratories is perhaps best characterized by its theme "*Mobility-Adaptability-Versatility,*" a theme that is reflected not only in its physical construction, but also in its working relationship with U. S. Stoneware.

The "Heinz Handbook of Nutrition," a 450-page compendium of information on nutrition for physicians, nutritionists, dietitians, nurses, home economists and public health workers, is presented to C. Lee Rumberger, (left), H. J. Heinz Company vice president in charge of research and quality control, by Dr. Benjamin Burton, Heinz nutrition specialist. Dr. Burton wrote the book with the active assistance of an editorial board of six nutritional authorities, including Dr. C. Glen King, Columbia University professor and executive director of the Nutrition Foundation Inc.

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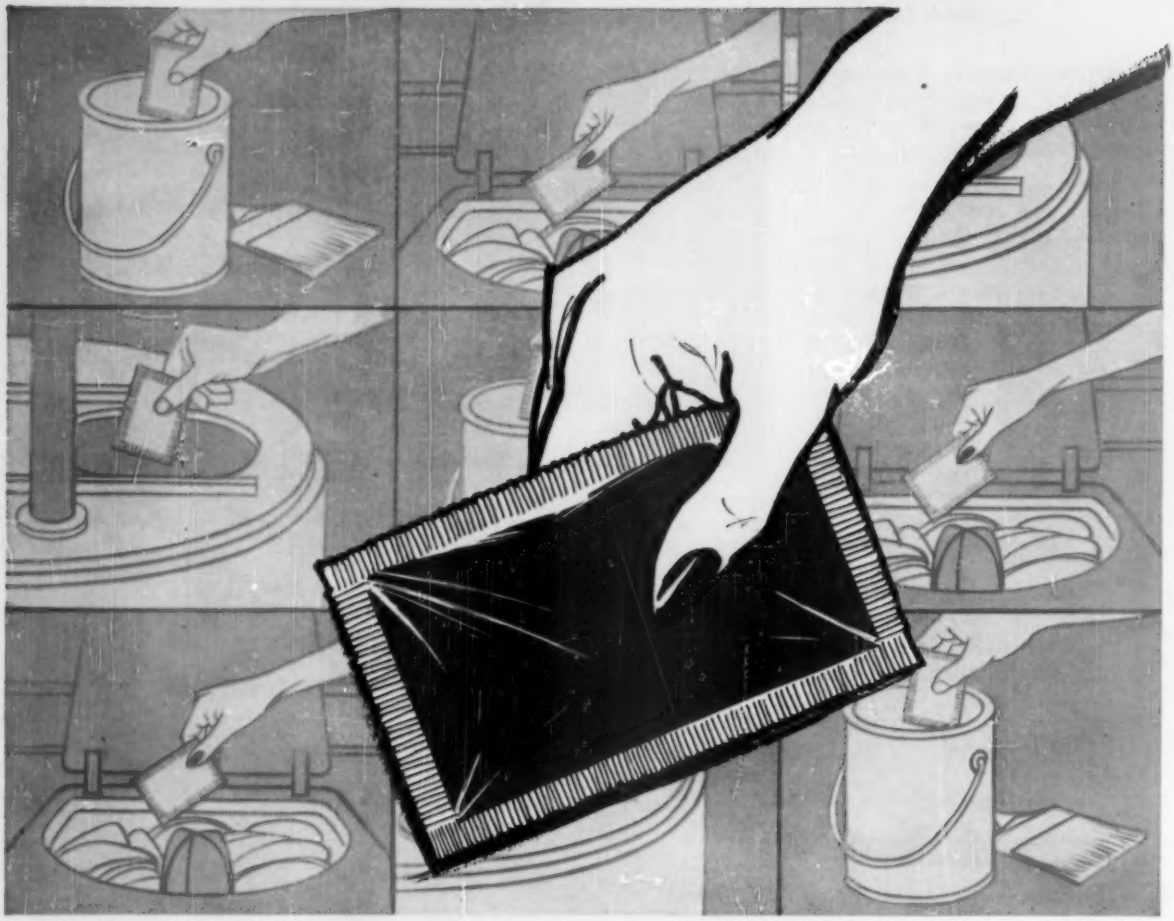

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Beckman Instruments, Inc. 28
Blaw-Knox Manufacturing Company ..... 9 and 10
Calgon Company 1
Chemo Puro Manufacturing Corporation 29
Corn Products Sales Company
Technical Section 740A
Diamond Crystal Salt Company
Technical Section 708D
Distillation Products Industries 14 and 15
Dodge & Olcott, Inc.
Technical Section 676B
Eastman Chemical Products, Inc 18
Epic Incorporated 20
Florasynth Laboratories, Inc. 27
Food and Drug Research Laboratories, Inc. 32
Food Materials Corporation
Technical Section 690A
The Foxboro Company
Technical Section 676A
Fries & Fries, Inc. 12
Fritzsche Brothers, Inc. 16
Givaudan Flavors, Inc.
Technical Section 708A
Hagan Chemicals and Controls, Inc. 1
Hercules Powder Company
Technical Section 690B
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The Meer Corporation 11
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Miles Chemical Company
Technical Section 726B
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Neumann-Buslee & Wolfe, Inc. 2nd Cover
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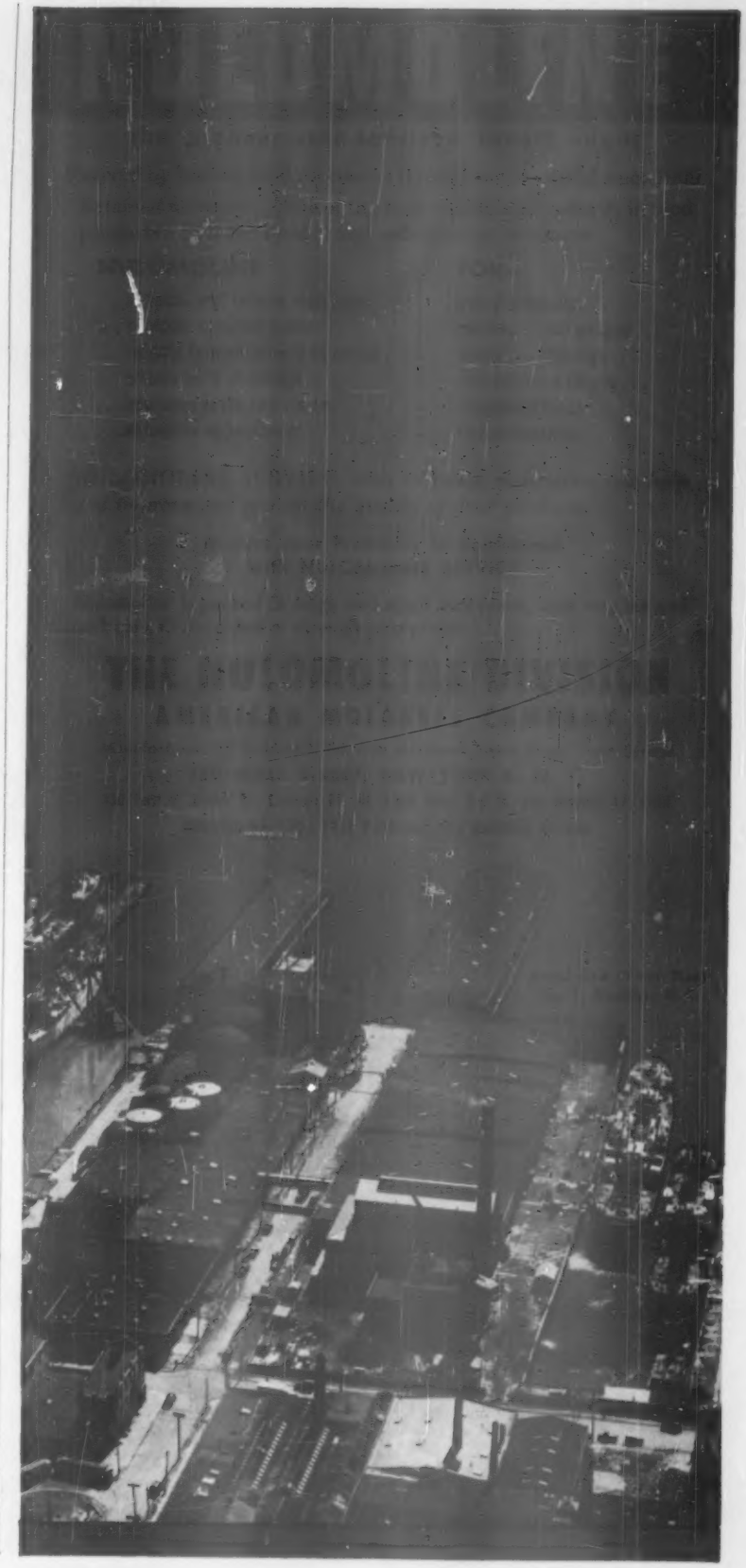

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